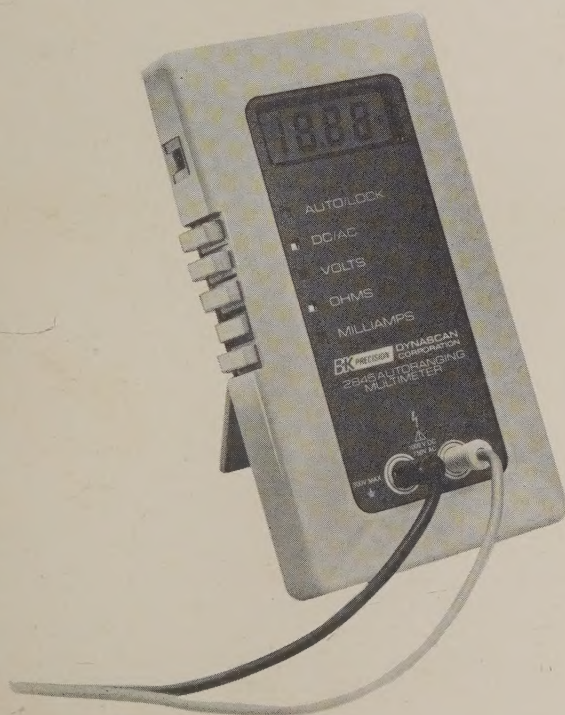


SERVICE MANUAL

2845

**Autoranging
DIGITAL
MULTIMETER**



TEST INSTRUMENT SAFETY

WARNING

Normal use of this instrument exposes you to a certain amount of danger from electrical shock because it is often used to measure high voltage, or to make other measurements in equipment that contains high voltage. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts dc or ac rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltage poses an even greater threat because it can more easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly. Remove housings and covers only when necessary. Turn off equipment while making test connections in high voltage circuits. Discharge high voltages capacitors after removing power.
2. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.
3. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; and make certain such surfaces are not damp or wet. Where insulated floor surface is not available, wear heavy gloves.
4. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a ground return path.
5. When using the test probe, touch only the insulated portion. Never touch the exposed tip portion.
6. Do not operate instrument unless rear case is in place and fully closed.
7. Disconnect test leads from equipment under test and from the multimeter before replacing batteries or fuses, and before performing any servicing on the multimeter.
8. Use B & K-Precision Model BE-16 Battery Eliminator *only* for operating this instrument from ac power. Do not use a calculator type battery eliminator. Calculator type units do not provide the protection necessary for floating the common test lead up to 500 volts dc. A shock hazard and serious internal damage may result.
9. When testing ac powered equipment, remember that ac line voltage is usually present on some power input circuits such as on-off switch, fuses, power transformer, etc. any time the equipment is connected to an ac outlet, even if turned off.
10. Many equipments with 2-wire ac power cords are transformerless "hot chassis" powered, where one side of the ac power line connects directly to the chassis. If such equipment does not have a polarized plug to prevent insertion the "wrong" way, a serious shock hazard exists if the chassis is touched. To make measurements in such equipment, always connect an isolation transformer between the ac outlet and the equipment under test. The B & K-Precision Model TR-110 Isolation Transformer is suitable for most applications. To be on the safe side, treat all 2-wire ac powered equipment as "hot chassis" unless you are sure it has an isolated chassis or an earth ground chassis. (However, the common jack of this multimeter is isolated from earth ground to permit it to be floated to a potential other than ground, up to 500 volts, for reference).
11. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

SERVICE MANUAL

for

B & K-PRECISION

Model 2845

Autoranging DIGITAL MULTIMETER

—WARNING—

This service manual is intended for use by qualified electronics technicians only. To avoid electric shock, do not perform servicing unless you are qualified to do so.

Exposed high voltage is present at various points in the meter whenever the front or rear case is removed and the test leads are connected to high voltage. Contacting exposed high voltage could result in fatal electric shock. Use the testing and troubleshooting techniques recommended in this manual, which rarely require application of high voltage.

BK PRECISION DYNASCAN
CORPORATION

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REFERENCE PUBLICATIONS

Model 2845 Autoranging Digital Multimeter Instruction Manual	480-298-9-001
Model 2845 Autoranging Digital Multimeter	
Composite (Schematic Diagram & Parts List)	499-190-9-001
Model BE-16 Battery Eliminator Instruction Sheet	481-124-9-001
Model PR-23 RF Detector Probe Instruction Sheet	481-045-9-001
Model PR-28 High Voltage Probe Instruction Folder	481-064-9-001
Model ES-28 10-Ampere Shunt Instruction Sheet	481-089-9-001
Model TP-28 Temperature Probe Instruction Manual	480-258-9-001
Model TP-28 Temperature Probe Composite	
(Schematic Diagram & Parts List)	499-154-9-001

DEFINITIONS OF SYMBOLS APPEARING ON METER



Read operating instructions.



High voltage terminals; 1000 volts or more may be present if connected to high voltage.

500V



Common input terminal. Connect to earth ground or point not more than 500 volts from earth ground.



Input terminal for dc (—), ac (—), or ohms (Ω).

1000 VDC
750 VAC
2A

Maximum input rating of $\bar{\Omega}$ terminal with respect to common input terminal.



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SPECIFICATIONS

SPECIAL FEATURES

Autoranging	Microcomputer controlled.
Auto Skip	For initial input greater than approximately 25 volts, unit immediately jumps to 200 V range. Eliminates stepping through two ranges and permits settling time of less than 1 second for 200 V range.
Range Lock	Enables user to lock into any range of any function. In range lock, overrange condition is indicated by blank digits (except continuous display of first digit "1" for reference) and flashing decimal points; decimal point for range that meter is locked onto does not flash.
Continuity Buzzer	Audible tone sounds continuously when resistance measures 179 ohms or less. User selectable and can be defeated at any time.
Safety Features	Fingers will not fit into test lead or battery eliminator jacks, mating plugs use recessed, non-exposed contacts. Warning and caution labels on front and rear case.

DC VOLTAGE

Ranges	± 2 V, 20 V, 200 V, 1000 V range, automatically selected.
Accuracy	$\pm 0.1\%$ of reading ± 1 LSD on all ranges.
Polarity Indication	Automatic; minus sign shown, plus sign implied.
Input Impedance	10 megohms.
Circuit Protection	1000 volts dc or dc + ac peak. Protected by metal oxide varistors and fuse.

AC VOLTAGE

(average responding circuitry calibrated to read rms value of pure sine wave)

Ranges	2 V, 20 V, 200 V, 1000 V (input limited to 750 volts rms), automatically selected.
--------	--

Accuracy

Range	50-200 Hz	200 Hz-1 kHz	1 kHz-5 kHz
2V, 20V	$\pm 0.5\%$ ± 3 LSD	$\pm 2\%$ ± 3 LSD	± 1 dB
200V, 1000V	$\pm 1\%$ ± 3 LSD	-	-

Input Impedance	10 megohms.
Circuit Protection	750 volts ac rms, 1000 volts dc + ac peak. Protected by metal oxide varistors and fuse.

DC CURRENT

Ranges	± 2 mA, 20 mA, 200 mA, 2000 mA, automatically selected.
Accuracy	$\pm 0.75\%$ of reading ± 1 LSD on all ranges.
Polarity Indication	Automatic; minus sign displayed, plus sign implied.
Voltage Burden	200 mV at full scale on 2 mA, 20 mA, and 200 mA ranges, 600 mV typical at full scale on 2000 mA range; measured across input terminals.

Circuit Protection	2 amp fuse and diodes.
--------------------	------------------------

AC CURRENT

Ranges	2 mA, 20 mA, 200 mA, 2000 mA automatically selected.
Accuracy	$\pm 1\%$ of reading ± 3 LSD, 50 Hz to 1 kHz.
Voltage Burden	200 mV at full scale on 2 mA, 20 mA, and 200 mA ranges, 600 mV typical at full scale on 2000 mA range; measured across input terminals.
Circuit Protection	2 amp fuse and diodes.

LSD = least significant digit

SPECIFICATIONS

RESISTANCE

Ranges 2 K Ω , 20 K Ω , 200 K Ω , 2000 K Ω , 20 M Ω , automatically selected with automatic K Ω or M Ω indicator.

Accuracy $\pm 0.3\%$ of reading ± 1 LSD on 2 K Ω to 2000 K Ω ranges. $\pm 0.6\%$ of reading ± 1 LSD on 20 M Ω range.

Polarity Red jack positive on all ranges.

Circuit Protection +1000 to -450 VDC or 300 VAC.

GENERAL

Display 3-1/2 digit 0.5" high-contrast LCD.

Operating Environment

0° to 55° C (18° to 28° for stated accuracy), 0 to 80% humidity.

Power Source

One 9-volt transistor battery (NEDA 1604 or equivalent), or optional BE-16 battery eliminator.

Battery Life

100 hours typical with alkaline battery. Automatic low battery indicator.

Dimensions

3-3/4 x 6-3/4 x 1-1/4" (95 x 175 x 30 mm)

Weight

1 pound (.45 kg).

Accessories Included

Built-in tilt stand, two safety test leads, spare fuses, instruction manual.

OPTIONAL ACCESSORIES

LC-45 CARRYING CASE

Zippered leatherette case with belt loop provides extra protection and convenience for field use. Includes storage space for probes.

BE-16 BATTERY ELIMINATOR

Permits operation from 120-volt, 60 Hz ac power, grounded outlet.

WARNING

Do not substitute a calculator type battery eliminator for the BE-16. Calculator type units do not provide the protection required for floating the common test lead up to 500 volts dc. A shock hazard and serious internal damage may result.

PR-21 ISOLATION/DIRECT PROBE

Has switchable 100 K Ω resistor to aid in measuring dc in rf circuits.

PR-23 RF DETECTOR PROBE

Permits measurement of rf signals from 15 kHz to 250 MHz.

PR-28 HIGH VOLTAGE PROBE

Extends maximum voltage capability to 40 kVDC, 20 kVAC at 60 Hz. 1000:1 divider lets meter reading in volts represent circuit voltage in kV. Input impedance is 600 M Ω .

ES-28 10-AMPERE SHUNT

Extends maximum current capability to 10 amperes. 1000:1 divider lets meter reading in milliamps represent circuit current in amps.

TP-28 TEMPERATURE PROBE

Converts the 2845 into a digital thermometer capable of -50° to $+150^{\circ}$ C (-58° to $+302^{\circ}$ F) measurements. Switch selectable $^{\circ}$ C or $^{\circ}$ F scales. Probe measures surface temperature of even small components, ambient air temperature at probe tip, or liquid temperatures by immersion of tip.

CONTROLS AND INDICATORS

(Refer to Fig. 1)

Power Switch. Turns unit ON and OFF.

Function Switches. Select the type of measurement to be performed; VOLTS, OHMS, or MILLIAMPS. Three interlocking pushbutton switches, pressing one releases previous selection.

DC/AC Switch. Selects DC or AC mode for VOLTS and MILLIAMPS functions. Alternate action pushbutton switch; push to latch in AC position, push again to release to DC position.

AUTO/LOCK Switch. Selects AUTO (autoranging) or LOCK (range lock) mode. Alternate action pushbutton switch; push to latch in LOCK position, push again to release to AUTO position. Continuity buzzer is enabled by shorting test leads together in OHMS function, then selecting LOCK mode.

"Mode Identifier" Windows. Color tabs on pushbutton switches show through these windows to identify which function and mode are selected. VOLTS, OHMS or MILLIAMPS

window shows white when corresponding pushbutton is engaged. AUTO/LOCK and DC/AC windows show white for AUTO and DC modes (pushbutton released) and red for LOCK and AC modes (pushbutton engaged).

⚡ WARNING

High voltage up to 1000 volts or more may be present on the test leads and test lead jacks when the test leads are connected to high voltage.

⏏ Jack (white). Input for black test lead. Common or reference side for all functions. The test lead connected to this jack is normally applied to the point nearer signal or earth ground. Maximum input rating 500 volts with respect to ground.

⏏ Jack (red). Input jack for red test lead. "Hot" or "high" side for all functions. The test lead connected to this jack is normally applied to the point more removed from signal or earth ground. Positive polarity for resistance measurements. Maximum input rating 1000 volts dc or 750 volts ac with respect to common jack, 2 amperes current.

Display. 3-1/2 digit LCD readout. Indicates numerical value of all measurements (maximum reading 1999). Automatic

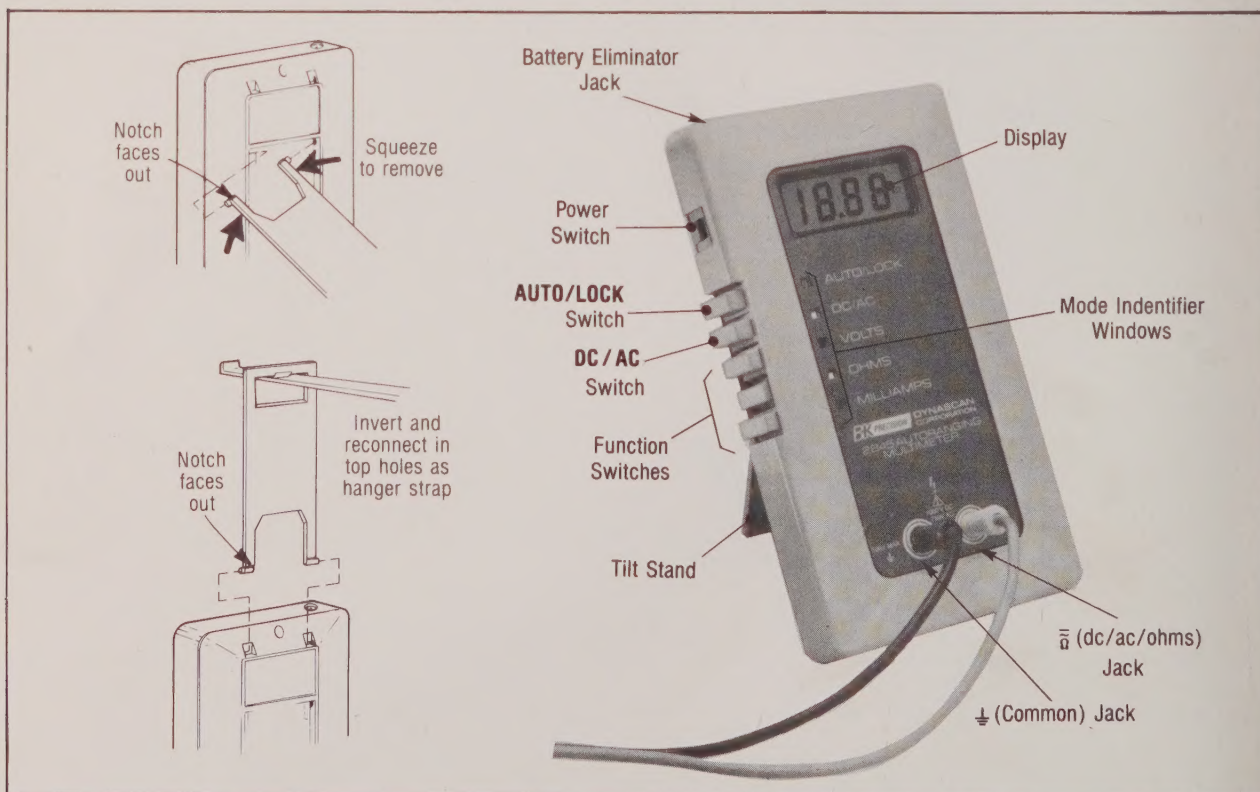


Fig. 1. Operating Controls.

decimal point placement. Indicate overrange condition by blank numerals (except first digit "1" displayed continuously) and flashing decimal points. The minus sign, K Ω , M Ω , and LO BAT indicators are also an integral part of the display:

Minus (-) Sign. Automatically displayed for negative polarity dc voltage or current. The plus sign is implied and not displayed. Polarity is that of hot input jack with respect to common input jack.

LO BAT Indicator. Automatically displayed when battery nears discharge; about 20% of useful battery life remains. Unit may be operated after LO BAT indication appears until battery discharges to 6.5 volts before accuracy of measurements is affected.

K Ω Indicator. Automatically displayed in OHMS function on all K Ω ranges.

M Ω Indicator. Automatically displayed in OHMS function on 20 M Ω range.

Battery Eliminator Jack. Connector for Model BE-16 accessory.

Tilt Stand. Folds out from rear case to provide convenient viewing angle for bench use. Also converts to use as hanger strap as shown in Fig. 1.

CIRCUIT ANALYSIS

OVERVIEW

Refer to block diagram, Fig. 2. The Model 2845 Autoranging Digital Multimeter operates by converting various types of inputs into a scaled dc voltage, which is then transformed into a digital readout by an A/D (analog-to-digital) converter.

A microcomputer controls automatic range selection (up-range, down-range, auto skip), range lock, K Ω and M Ω display, and continuity buzzer. The instrument is designed around a 4-bit microcomputer (IC7). This single 40-pin microcomputer chip includes the microprocessor, 1024 x 8 bit ROM (read only memory) for program storage, and 48 x 4 bit

RAM (random access memory) for data storage. Range selection is made by sealed reed relays K1 thru K4. Relay activation, decimal point, and K Ω or M Ω symbol selection are under the control of the microcomputer. Table 1 summarizes the selections made for each range.

All voltage inputs are applied across a 10-megohm voltage divider network (resistor network RN-1). A decade fraction of that voltage is selected by relay K1 to K4 and applied to A/D converter IC2. For an on-scale reading, this voltage is between -0.1999 and $+0.1999$ volt. For ac voltage, the input is first routed through ac/dc converter IC1 which rectifies the ac and produces a dc output which is calibrated to be proportional to the rms value of a sine wave ac voltage input.

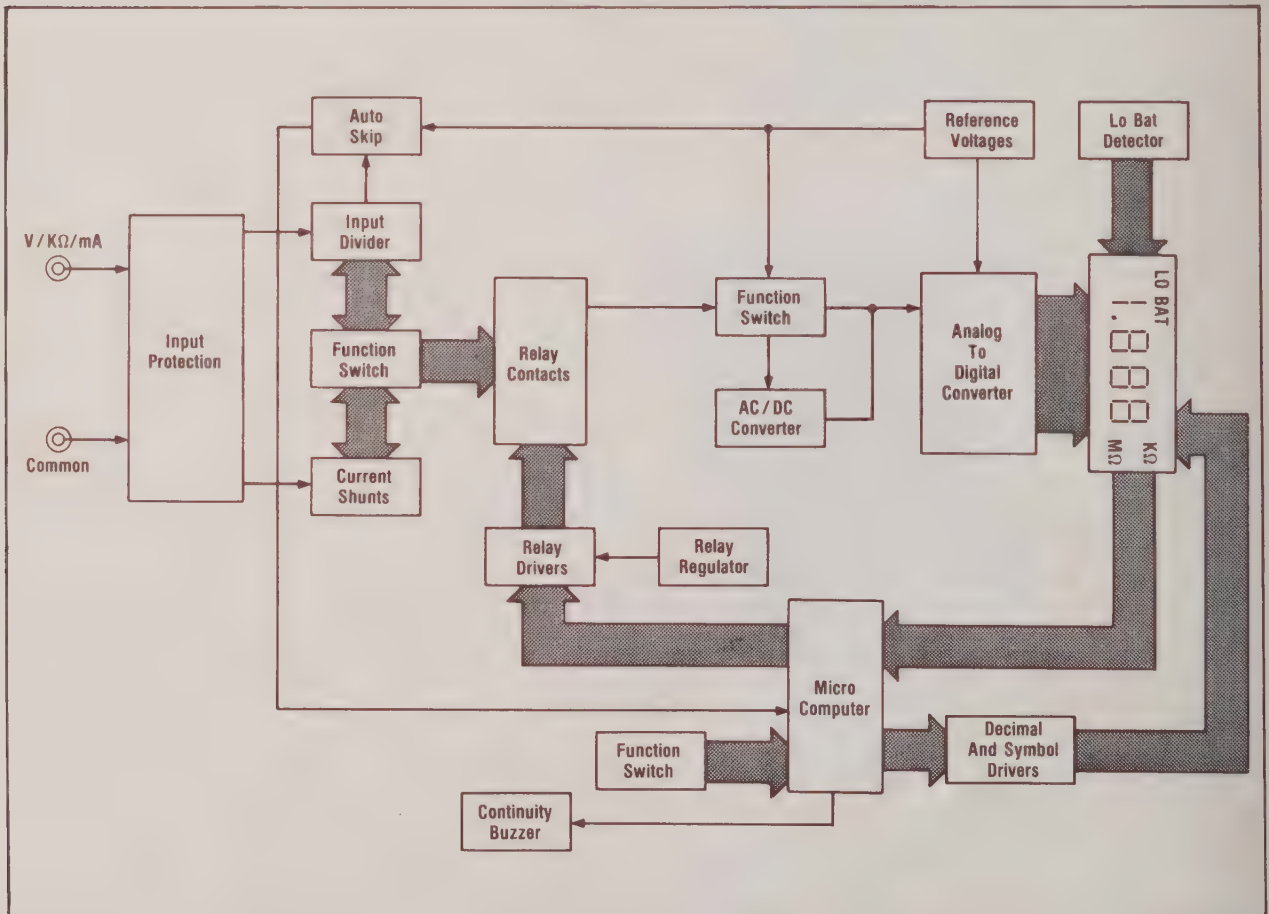


Fig. 2. Block Diagram.

FUNCTION	RANGE	RELAY ENERGIZED	DECIMAL POINT ENABLED	ATTENUATION	SYMBOL ENABLED
VOLTS and MILLIAMPS	2 V/2 mA	K1	D.P. 1	1:1	—
	20 V/20 mA	K2	D.P. 2	10:1	—
	200 V/200 mA	K3	D.P. 3	100:1	—
	1000 V/2000 mA	K4	none	1000:1	—
OHMS	2 K Ω	K4	D.P. 1	—	K Ω
	20 K Ω	K3	D.P. 3	—	K Ω
	200 K Ω	K2	D.P. 3	—	K Ω
	2000 K Ω	K1	none	—	K Ω
	20 M Ω	none	D.P. 2	—	M Ω

Table 1. Relay, decimal point, and symbol selection summary.

Using the dual-slope integration technique, the A/D converter produces digital outputs which correspond to the analog value of its input. The digital signals are converted to numerical digits by the LCD display. The microcomputer is programmed to interpret certain of the digital signals from the A/D converter and automatically control range selection, decimal point placement, and the other functions under control of the microcomputer. Upon command, the microcomputer reads selected digital outputs of the A/D converter into its memory and compares each two consecutive sets of data. If two consecutive data readings are equal, the data is then stored in memory. This reading and comparing of data eliminates a potential source of instability. The digital information stored in memory is constantly being refreshed to insure accurate and reliable operation.

Resistance is measured by a ratiometric technique, where the unknown resistance is compared against a known resistance (selected segments of resistor network RN-1). A reference voltage is applied across the series circuit of the known and unknown resistances. The ratio of the two resistances is equal to the ratio of voltage drop across each. The voltages developed across the known and unknown resistance are both applied to the A/D converter, computed, and the value of the unknown resistance displayed.

For current measurements, the input is passed through one of four small shunt resistances selected by relay K1 to K4. The voltage drop produced across the selected shunt is directly proportional to the input current. This voltage is applied to the ac/dc converter for ac, or directly to the A/D converter for dc.

The function and mode switches determine which of the programs stored in ROM is to be executed. In the autoranging mode, the microcomputer produces an up-range command if the count is greater than 1999. The up-range command selects the next relay, shifts the decimal point, etc. as summarized in Table 1. A count of 179 or less produces a down-range command, with similar results in reverse. The up-range or down-range stepping continues until a count of 180 to 1999 results, or the highest or lowest range is reached. In the range lock mode, the up-range command initiates the

overrange display. If range locked in the lowest resistance range, the down-range command (179 ohms or less) actuates the continuity buzzer.

The auto skip circuit is a threshold detector, sensing a point on the input voltage divider. It has the ability to detect positive or negative polarity input voltage that exceeds its threshold of approximately 25 volts. When its threshold is exceeded, it produces an "auto skip" command to the microcomputer. If range 1 is selected when this command is applied, it immediately skips to range 3 (200 V range). For example, touching the meter probe to 240 volts skips the meter to the 200 V range. It then up-ranges to the 1000 V range for an on-scale reading. This eliminates stepping through the 2 V and 20 V ranges and gives much faster settling time.

A/D CONVERTER

A detailed circuit analysis of the analog-to-digital converter is given first because its operation is vital to the basic understanding of the entire multimeter. The dual-slope integration technique of analog to digital conversion is used. This is the method used in most digital multimeters. In this meter, integrated circuit IC2 performs this function. The conversion process is accomplished in three distinct steps: autozero, integrate, and de-integrate. The conversion process is continually repeated at the rate of three times per second. Thus, the digital reading is continually updated.

The digital portion of the A/D converter includes an oscillator (or clock), timing circuits to time and control the three steps of conversion, a counter to provide the digital reading, and several solid state switches to interconnect the analog circuits into the three configurations required for the three steps of conversion. Naturally, it also includes the necessary digital control circuits to automatically operate the solid state switches.

The analog circuits include the three op-amps shown in Fig. 3; a very high input impedance buffer, an integrator, and a comparator. A few components external to IC2 also play an important role in this circuit, specifically, reference capacitor C9, autozero capacitor C11, integrate capacitor C12 and integrate resistor R15.

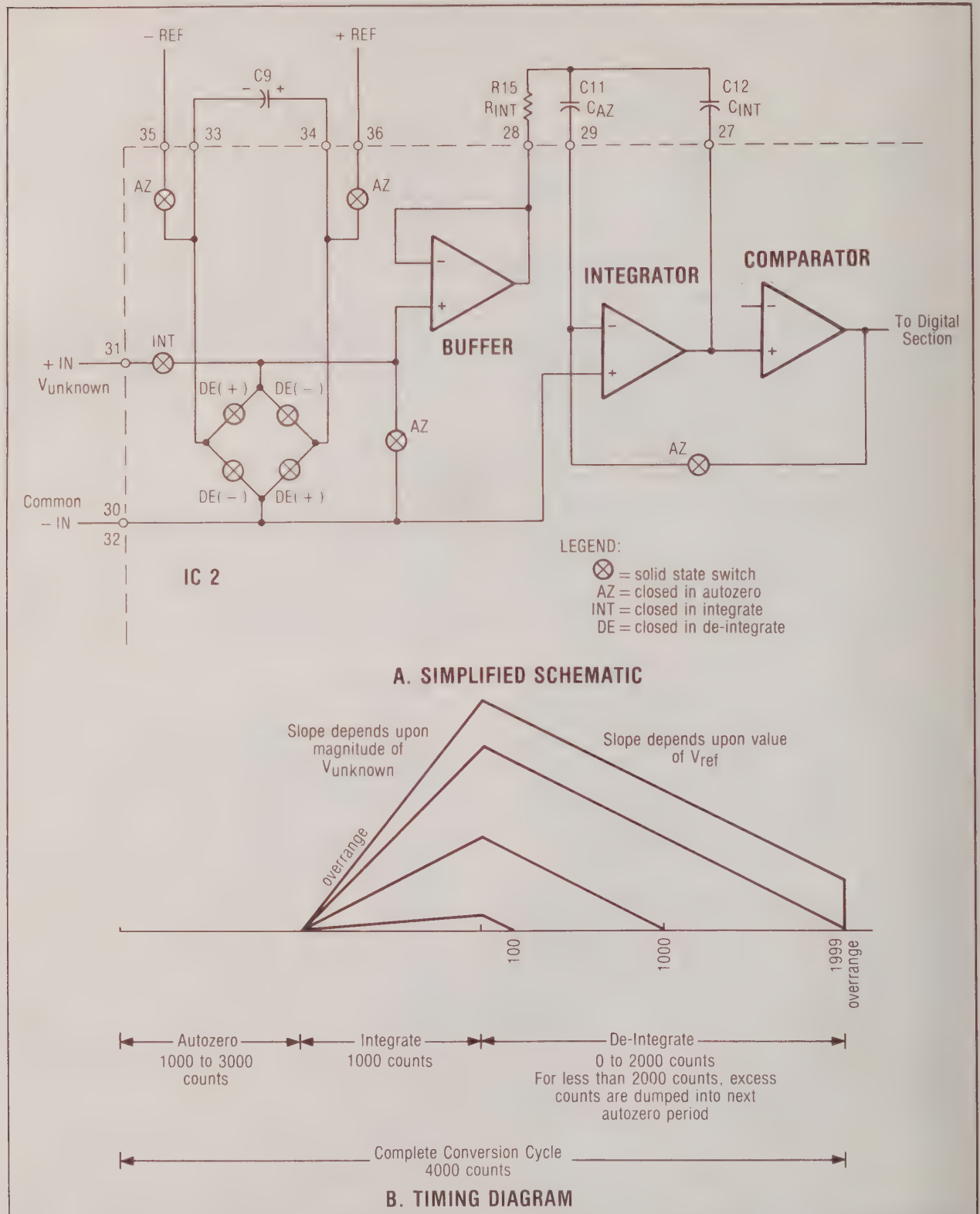


Fig. 3. A/D Converter.

Timing

The oscillator, or clock, operates at 48 kHz, although its output is buffered by a $\div 4$ divider so that a 12 kHz clock signal feeds the counter. External components R14 and C10 determine the frequency of the clock. The 48 kHz frequency gives the three readings per second rate, and high common mode rejection at 60 Hz.

A complete conversion cycle requires 4000 counts of the counter. The autozero period is 1000 to 3000 counts, the integrate period is a fixed period of 1000 counts, and the de-integrate period is variable from 0 to 2000 counts. At full scale, the autozero period is 1000 counts and the de-integrate period is 2000 counts. At less than full scale, the de-integrate count is less than 2000. The excess counts are dumped into the next autozero period, so that the complete conversion cycle remains fixed at 4000 counts.

Autozero

During the autozero period, the analog circuits are interconnected as shown in Fig. 3 with the AZ switches closed. The reference voltage is impressed across C9 and it charges to that value. The comparator output is fed back to the integrator input, and the entire amplifier loop operates as a voltage follower. The common is applied to the input of the buffer. Ideally, the output should be exactly equal to the input (zero). Actually, however, each op-amp has a slight dc offset which may be of either polarity. The cumulative offsets of the three op-amps may cause the output to differ slightly from the input. However, any difference is stored on autozero capacitor C11, which re-inserts the voltage during the integrate and de-integrate periods to effectively cancel the error. As the conversion process is continually repeated, the circuit is automatically re-zeroed before each reading.

Integrate

During the integrate period, the circuit is interconnected as shown in Fig. 3 with the INT switch closed. The feedback path of the comparator and integrator is now open, and the circuits operate as an integrator and comparator. The reference voltage is removed from capacitor C9 and it retains the reference voltage charge. The input of the buffer is connected to the unknown voltage being measured. For an on-scale reading, this voltage is between 0 and 0.2 volt, and may be of either positive or negative polarity. The integrator circuit produces a linearly increasing voltage. The slope is dependent upon the magnitude of the unknown input voltage and the direction of the slope is dependent upon the polarity of the input. The higher the unknown voltage, the steeper the slope at the ratio of $V_{\text{unknown}}/R15$. A positive polarity input will produce a negative-going slope and vice versa. At the end of the integrate period, integrating capacitor C12 is charged to a voltage proportional to the unknown input voltage. With a 48 kHz clock, the integrate period is an exact multiple of 60 Hz. This results in maximum common mode rejection because any 60 Hz interference is at the same point of its cycle at the beginning and end of the integrate period.

De-Integrate

During the de-integrate period, the circuit is interconnected as shown in Fig. 3 with the DE switches closed. The unknown voltage is removed from the buffer, and the reference voltage that was stored on reference capacitor C9 is applied. Note that either polarity of voltage may be applied, depending upon whether the DE(+) or DE(-) switches are closed. The digital control circuits detect the polarity of the unknown voltage during the integrate period and automatically select the opposite polarity during the de-integrate period. The integrator components now produce a linearly decreasing voltage at the ratio of $V_{\text{ref}}/R15$. The de-integrate period continues until the voltage returns to the autozero reference level. The counter was reset at the beginning of the de-integrate period, and it counts clock pulses until the autozero level is reached. At this point, the counter output is latched into the display and another autozero period is started. If the counter reaches a count of 2000 before this occurs, an over-range pulse blanks the display and ends the de-integrate period.

For voltage and current measurements, the reference voltage is a fixed voltage of 0.1 volt, and the de-integrate slope is fixed. However, for resistance measurements, V_{ref} is dependent upon the value of resistance being measured. In turn, the de-integrate slope is dependent upon the value of V_{ref} . In either case, however, the digital output at the end of the de-integrate period equals $1000 \frac{V_{\text{unknown}}}{V_{\text{ref}}}$.

Display Circuits

Integrated circuit IC2 also contains the digital circuits which convert the counter output into display control signals, and the display drivers. These circuits are fully described in the DISPLAY paragraphs.

DC VOLTAGE MEASUREMENT

See Fig. 4 for a simplified diagram of the dc voltage measurement circuit. As stated earlier, the input voltage applied to the A/D converter (V_{unknown}) must be less than 0.2 volt for an on-scale reading. Therefore, the 0-2 V, 0-20 V, 0-200 V, or 0-1000 V input (depending upon range) must be scaled down to 0.2 volt maximum. This is accomplished by resistor network RN-1 and relays K1 thru K4.

The voltage applied at the input jacks of the meter is developed across the total 10-megohm resistance of RN-1. On the 2 V range, relay K1 is energized. The voltage developed across the 1-megohm portion of RN-1 is applied to the A/D converter. Due to the precision of divider network RN-1, this is an accurate 10:1 attenuation of the input applied to the meter.

On the 20 V range, relay K2 is energized and the A/D converter input is developed across the 100-kilohm portion of RN-1. Attenuation is 100:1. The 100:1 tap of the divider network also feeds the auto-skip circuit. On the 200 V range, relay K3 is energized and attenuation is 1000:1. When relay K4 is energized on the 1000 V range, attenuation is 10,000:1.

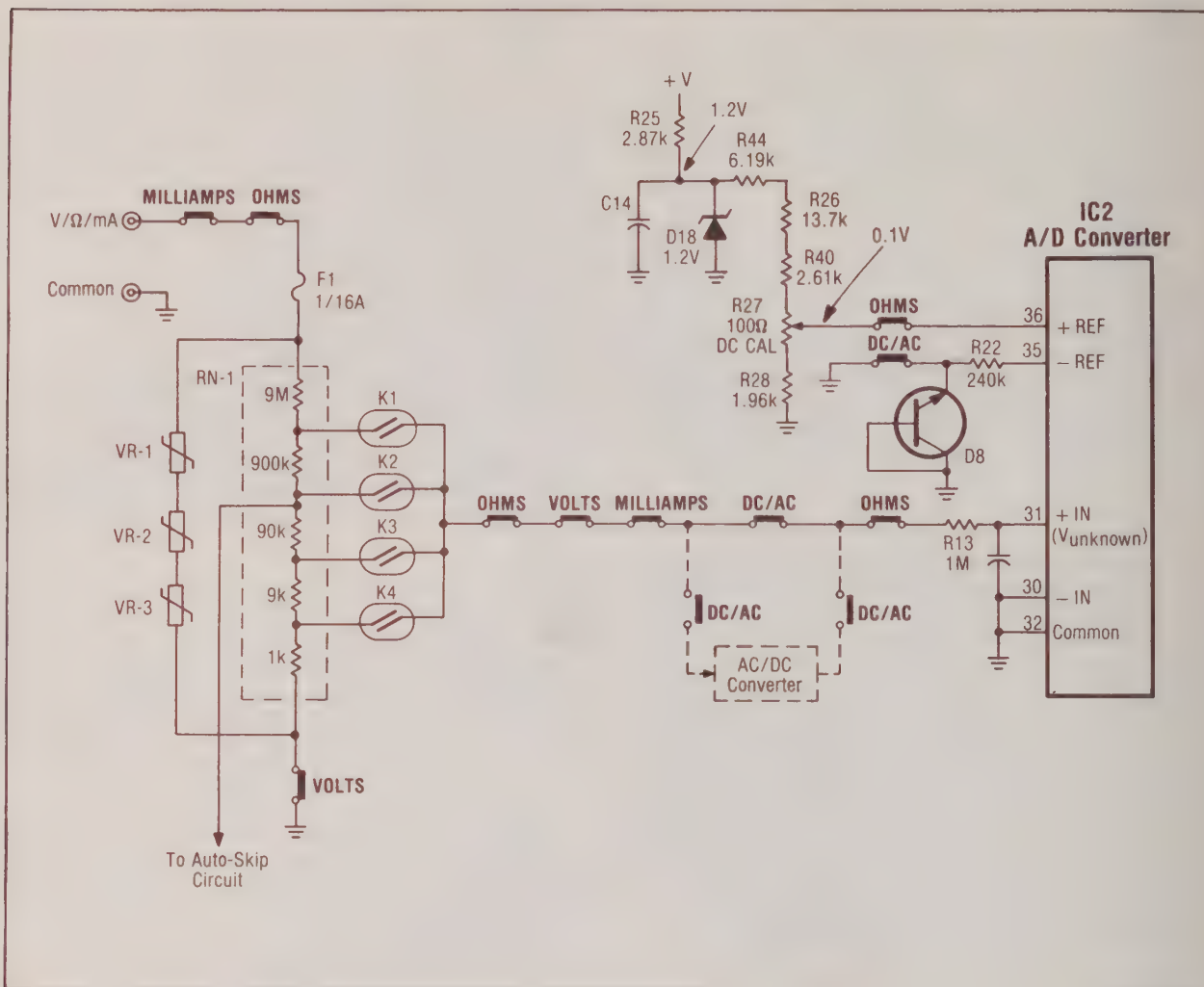


Fig. 4. Voltage Measurement Circuit.

The dc voltage accuracy of the meter is primarily dependent upon the precision of divider network RN-1.

Resistor R13 acts as a current limiter to protect IC2. Under normal operation, up to 1000 volts may be applied to the meter input jacks. Therefore, up to 100 volts is present at the contacts of relay K1 when the meter is on range 1. IC2 needs the protection offered by R13 in this situation.

Zener diode D18 establishes a stable 1.2 volt reference voltage. A divider network consisting of R44, R26, R40, R27, and R28 divide the 1.2 volt reference down to 0.1 volt at the + REF input of the A/D converter. This value is adjustable within a narrow range by DC CAL potentiometer R27.

Calibration consists of adjusting the reference voltage, which adjusts the fixed slope of the de-integrate period in the

A/D converter. Adjustment of the slope, in turn, varies the duration of the de-integrate period for a given input voltage. By applying a known voltage of near full scale and adjusting R27 for an accurate reading, the A/D converter is accurate for all other values.

Overload protection is given by metal-oxide varistors (MOV's) VR-1 to VR-3 and fuse F1. The series combination of VR-1, VR-2 and VR-3 has a conduction threshold of slightly above 1000 volts. Below 1000 volts, they appear as an open circuit. Above the conduction threshold, the resistance of the MOV's begins to drop, shunting part of the input around the resistor network. This places a load on the external voltage source connected to the meter's input terminals. A low energy voltage source may become loaded down sufficiently to drop the voltage. A voltage source with sufficient energy to sustain 1/16 amp or greater will blow F1.

AC VOLTAGE MEASUREMENT

All the circuits shown in Fig. 4 are also used for ac voltage measurements, except the DC/AC switch contacts are in the opposite condition from that shown. The scaled ac voltage from resistor network RN-1 is then applied to the ac/dc converter. The ac input voltage is converted into a dc output voltage. Although the rectifier circuit responds to the average value of the applied ac voltage, the dc output is adjusted for a value equal to the rms value of a pure sine wave ac input. The ac/dc converter circuit is shown in Fig. 5.

The scaled ac input voltage is capacitively coupled to amplifier IC1. Resistor R5 gives current limiting protection for IC1. Additional overvoltage protection is given by diodes D4 and D7, which are forward biased if the input exceeds the +V and -V supply voltage respectively. The amplified ac is rectified by diodes D5 and D6. The gain of the amplifier is controlled by the amount of feedback returned to the inverting input of the amplifier. Capacitor C5 couples the ac feedback only, which is adjustable. Resistor R6 provides a fixed amount of dc feedback. The positive polarity dc output developed through half-wave rectifier D6 is filtered and applied to the A/D converter. Calibration of ac measurements is adjusted by R11, which adjusts the gain of amplifier IC1.

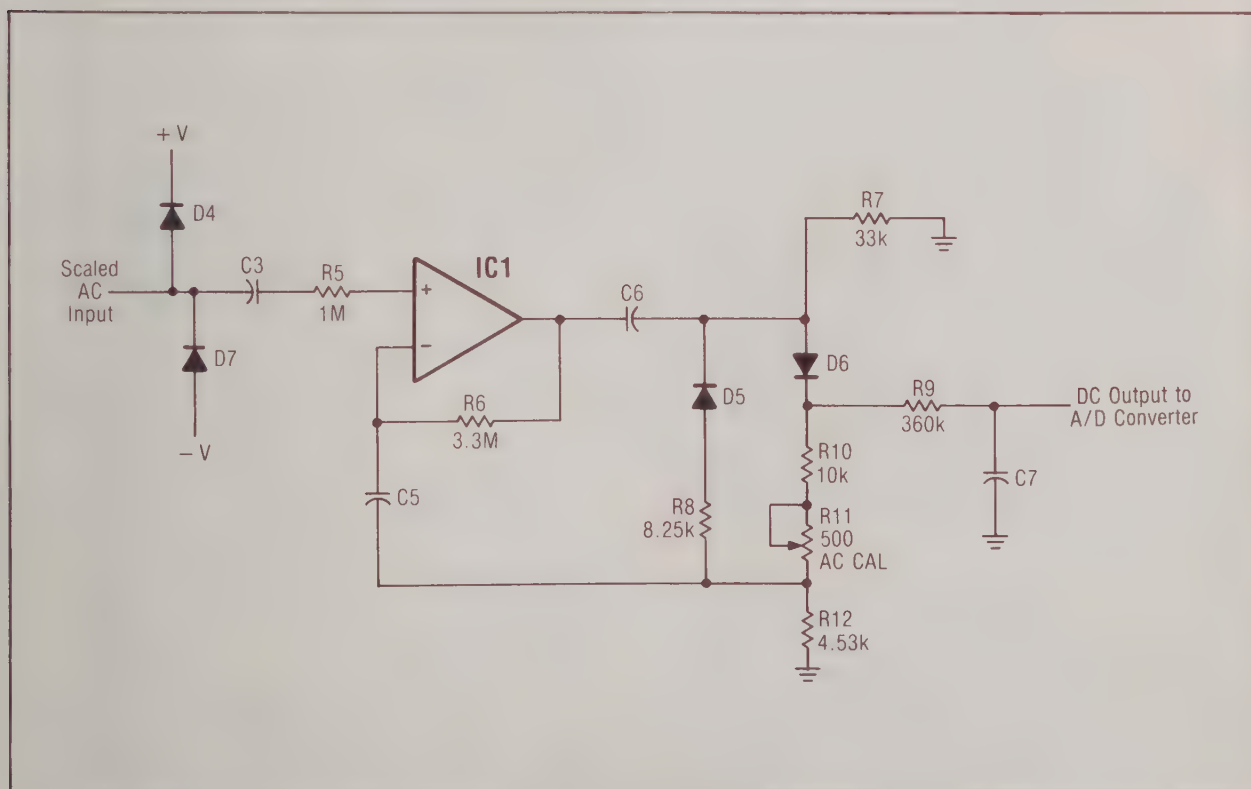


Fig. 5. AC/DC Converter.

CURRENT MEASUREMENT

Fig. 6 is a schematic diagram of the current measurement circuit. When the MILLIAMPS function is selected, the input jacks of the meter are connected in series with one or more shunt resistors, R1 thru R4. Relays K1 thru K4 select shunt resistances of 100 ohms (K1 energized, 2 mA range), 10 ohms (K2, 20 mA), 1 ohm (K3, 200 mA), or 0.1 ohm (K4, 2 A). The current passing through the selected shunt resistance develops a scaled dc or ac voltage which is proportional to the magnitude of the current. The scaled dc voltage is applied directly to the A/D converter, and measurement is exactly the same as voltage. For ac current measurement, the scaled ac voltage is applied to the ac/dc converter and measured exactly like an ac voltage.

Accuracy is dependent upon the precision of the current shunts, and no separate calibration adjustment is required.

Overload protection is given by diodes D1, D2, D21, and D22, and fuse F2. The series diodes have a forward voltage drop of about 1.4 volt, and therefore limit the maximum instantaneous voltage across the input terminals to ± 1.4 volt. Fuse F2 limits the maximum average input current to 2 amps. Both types of protection limit the maximum dissipation in the shunt resistors to protect them from damage from accidental overload.

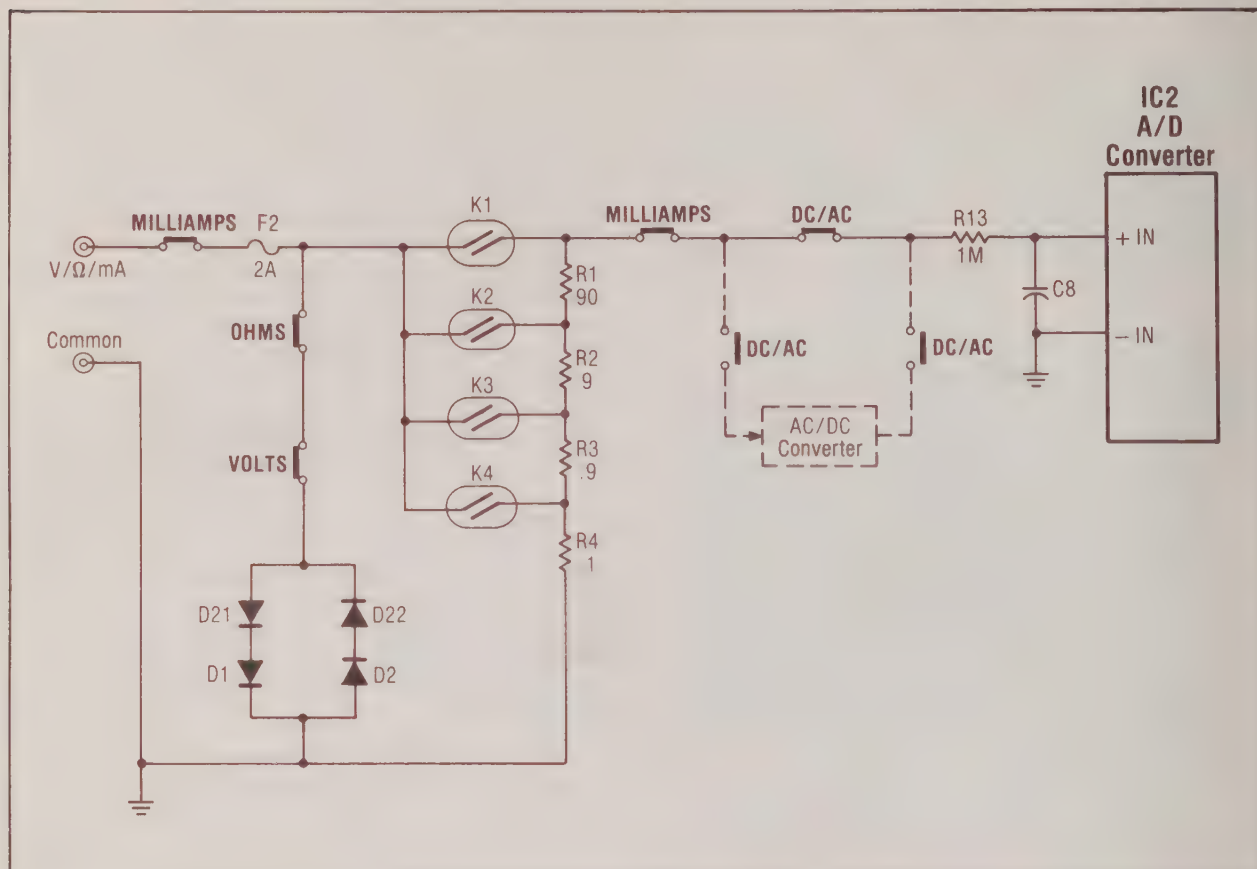


Fig. 6. Current Measurement Circuit.

RESISTANCE MEASUREMENT

Resistance is measured by a ratiometric technique, where the unknown resistance is compared against a known resistance. Fig. 7 shows a simplified example of the circuit configuration used during resistance measurements. A reference voltage is applied across the series circuit of a standard resistor and the unknown resistance. The ratio of the voltages developed across these two resistances is equal to the ratio of resistance. The voltage developed across the standard resistor is applied as the V_{ref} to the A/D converter, and the voltage developed across the unknown resistance is applied to the $V_{unknown}$ input of the A/D converter. As previously explained, the output of the A/D converter equals $1000 \frac{V_{unknown}}{V_{ref}}$.

For example, if a standard resistor of 1 megohm is selected and the unknown resistor is 800 kilohms, and a reference voltage of 0.9 volt is applied across the series circuit of both resistors, 0.5 volt will be developed across the standard resistor and 0.4 volt will be developed across the unknown resistor. Substituting the voltage values into the equation, $display = 1000 \frac{V_{unknown}}{V_{ref}}$, a reading of 800 KΩ would be displayed. In another example, a standard resistor of 10 kilohms is selected and the unknown resistance is 2 kilohms. The

0.9 volt reference would be divided 0.75 volt across the 10 kilohm standard resistor and 0.15 volt across the unknown 2 kilohm resistor. The ratio of 0.75 to 0.15 is 5:1 or 0.2, which would be displayed as 2.00 KΩ.

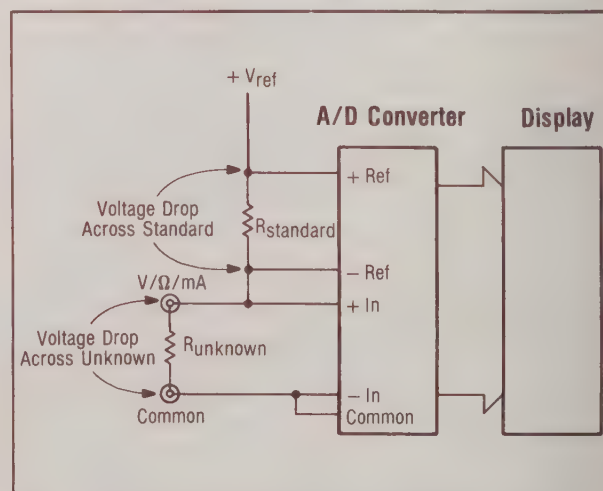


Fig. 7. Ratiometric Resistance Measurement, Simplified Circuit.

Fig. 8 shows a more detailed view of the OHMS measuring circuit. The 0.9 volt reference is developed from a regulated 1.2 volt source across divider network R44, R26, R40, R27 and R28. This voltage is applied across the selected portion of resistor network RN-1 and the unknown resistance connected at the input terminals of the meter. Range selection relays K1 thru K4 select the value of standard resistor to be used. Standard values of 1 k Ω , 10 k Ω , 100 k Ω , 1 M Ω , and 10 M Ω are selected by operation of relays K4, K3, K2, K1 and no relays respectively. The precision of the 0.9 volt reference is not critical with the ratiometric method of measurement. Accuracy is dependent upon the precision of the resistance values of the standard resistors in RN-1, and no separate calibration adjustment is required.

Diodes D15 and D8 and PTC (positive temperature coefficient) resistor R24 offer circuit protection if a voltage is ac-

cidentally applied at the input terminals when the OHMS function is selected. During normal operation, the resistance of R24 is negligible, diode D15 is forward biased, and diode D8 is reverse biased. If a positive polarity input voltage (or the positive swing of an ac voltage) is accidentally applied, diode D15 is reverse biased. Up to its PIV rating of 1000 volts, D15 blocks the input voltage from the resistor network and the V_{ref} input of IC2. As previously described, R13 provides current limiting protection for the $V_{unknown}$ input of IC2. If a negative polarity input voltage is applied (or the negative swing of an ac voltage), a conduction path is established through forward biased diodes D15 and D8 and the PTC resistor, R24. D8 clamps the V_{ref} input of IC2 at -0.7 volt maximum. Conduction through R24 causes almost instantaneous heating, with a corresponding sharp increase in its resistance. This circuit can withstand up to -400 volts. R24 cools rapidly when the voltage is removed, causing no noticeable delay for stabilization of the meter.

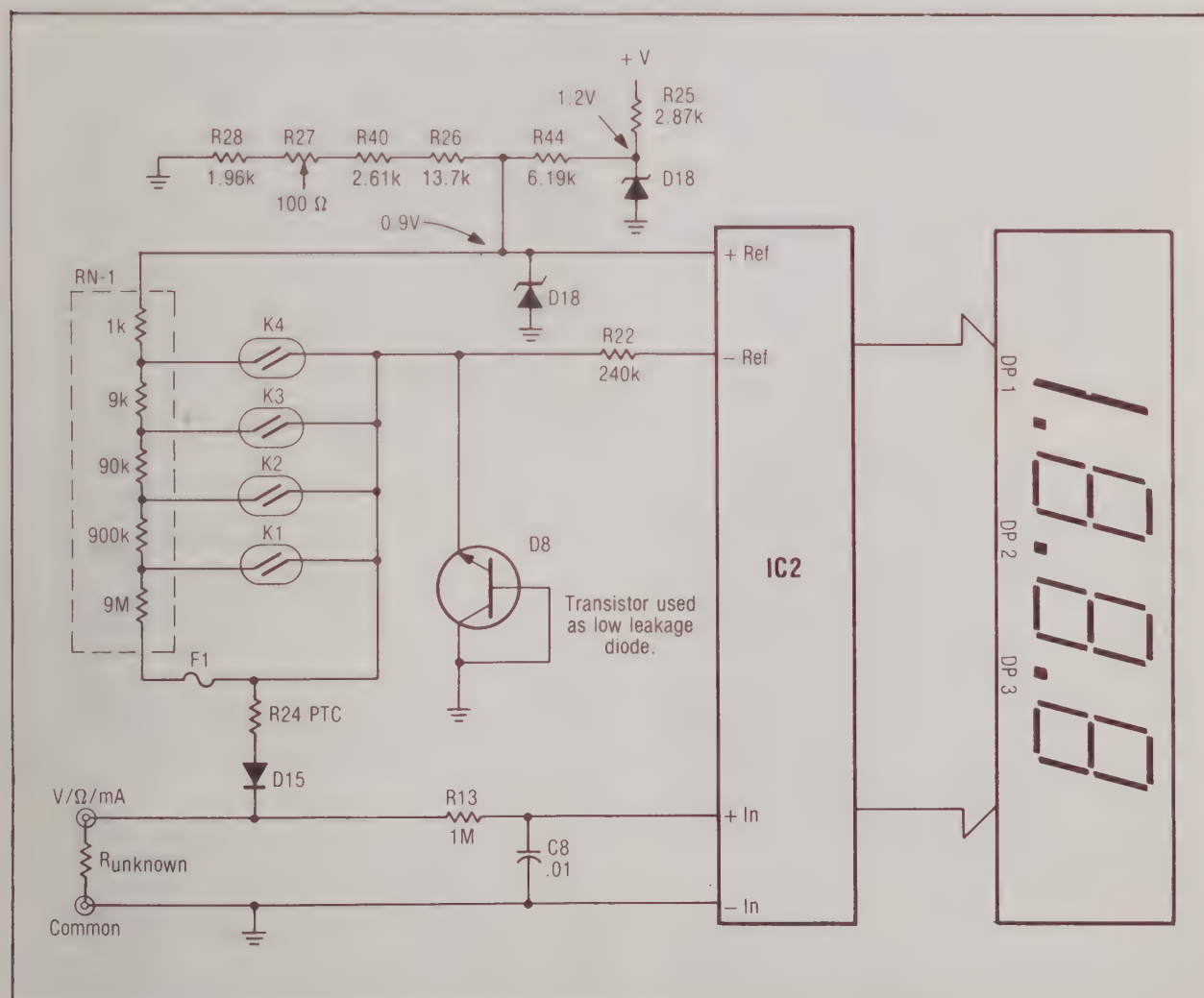
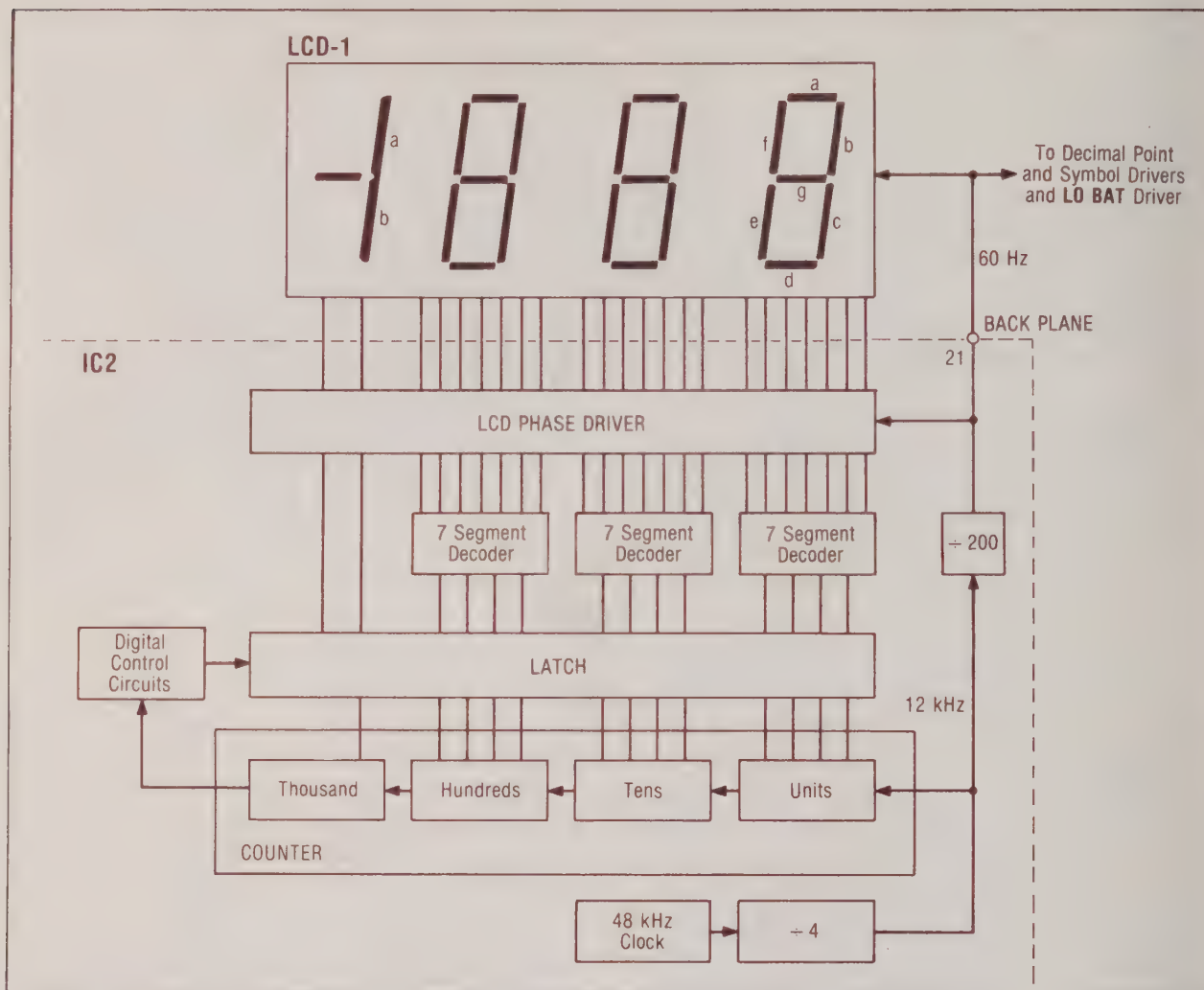


Fig. 8. Resistance Measurement Circuit.



DISPLAY

Fig. 9 is a simplified schematic diagram of the display circuits. The 3-1/2 digit readout is displayed on liquid crystal display LCD-1. The units, tens, and hundreds digits are each made up of seven individually controlled segments which can display any numeral from 0 to 9. A 60 Hz square wave signal is applied to the backplane of the display. Each segment is driven by a 60 Hz signal that is either in phase or out of phase with the backplane signal. Out-of-phase signals (difference of potential) cause the corresponding segment to be displayed. The segment remains off when the signals are in phase (equal potential). The fourth digit (thousands) is either blank or displays a "1". Thus, readings up to 1999 are obtainable.

Most of the circuits which drive the display are included in integrated circuit IC2, the A/D converter. LCD displays are characterized by low power consumption and long battery life. The resultant low heat sinking requirements of the LCD segment drivers permit them to be incorporated into IC2.

The counter continuously counts 12 kHz clock pulses. As mentioned earlier in the A/D converter circuit analysis, the counter always starts the de-integrate period at a count of 0000. At the end of the de-integrate period, the digital control circuits operate the latch. The output of the counter is then latched into the decoders and drivers until the next A/D conversion cycle. The process is continuous at the rate of 3 times per second.

The counter output is in BCD (binary coded decimal) format. The 7-segment decoders convert the BCD format into seven individual binary outputs. The LCD phase drivers, in turn, convert each binary output into a 60 Hz segment drive signal that is either in phase or out of phase with the backplane signal, depending upon the binary state of its input. The 60 Hz backplane signal, which also drives the LCD phase drivers, is developed from the 12 kHz clock signal by the $\div 200$ divider in IC2.

The counter registers clock pulses to 1999, and, at the next clock pulse, advances to 0000. The 1-to-0 transition of the thousands counter is an overrange signal to the digital control circuits. The digital control circuits then blank the first three digits of the display and latch the fourth digit on.

Polarity of the input is detected in the A/D converter. The digital control circuits provide a binary output representing positive or negative polarity. This binary signal is converted to a 60 Hz segment drive signal for the display's minus sign by the LCD phase driver.

MICROCOMPUTER

Autoranging is under control of the microcomputer, IC7. IC7 is a custom 4-bit microcomputer, which includes the microcomputer and integral 1024 x 8 bit ROM for program storage and 48 x 4 bit RAM for data storage. All data is entered into two parallel ports and two interrupt ports of the microcomputer. All data required for operation is obtained from the function switches and certain segment drivers of the display. The function switches determine which of the programs in memory will be selected. The 60 Hz backplane signal is used as a master clock signal for data retrieval and delay timing. The outputs of certain segment drivers for the display are also applied to the parallel ports of the microcomputer. Only those segments identified in Fig. 10 are used; that is, the most significant digit D4, segments a, b, d, and g of third digit D3, and segments a, b, f, and g of second digit D2.

Data retrieval begins with execution of instructions which tell the microcomputer to monitor the backplane signal. Upon a low-to-high transition of the backplane signal, data from the nine monitored display segment drivers are entered into the microcomputer and stored in RAM. This reading and storing of data is repeated, then the two sets of data are compared. If the compared data are not the same, the microcomputer continues to enter, store, and compare data. Only when two consecutive data retrievals are equal will program execution continue. This comparing of data ensures that the display reading has stabilized and protects against false program execution from noise or transients. The data stored in RAM is constantly refreshed and up-dated.

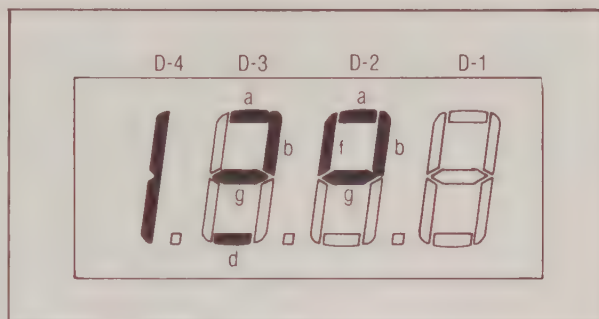


Fig. 10. These display segments are monitored as input data to the microcomputer.

Autoranging

Range selection is performed by relays K1 thru K4, although relay activation is controlled by the microcomputer, as is the corresponding decimal point placement. Range selection results from the autoranging program stored in ROM. Table 2 summarizes the autoranging steps. Note, for example, that the autoranging program for the OHMS function is different from the VOLTS and MILLIAMPS function. The sequence of relay activation is in the opposite order, and the K Ω or M Ω symbol is enabled only in the OHMS function.

All information necessary for proper range selection is derived from the data in RAM; that is, up-ranging and down-ranging. Whenever the microcomputer interprets the monitored segment driver signals as a value greater than 1999, an up-range command is generated. The up-range command steps the microcomputer to the next higher range. The next relay is energized and the corresponding decimal point is activated. In the OHMS function, the proper K Ω or M Ω symbol is also activated.

When the microcomputer interprets the monitored segment driver signals as a value of 179 or less, a down-range command is generated. The down-range command steps the microcomputer to the next lower range. The relay and decimal point, and K Ω symbol if applicable, for the next lower range are activated.

FUNCTION	RANGE	RELAY ENERGIZED	DECIMAL POINT ENABLED	SYMBOL ENABLED
VOLTS and MILLIAMPS	2 V/mA	K1	D.P. 1	—
	20 V/mA	K2	D.P. 2	—
	200 V/mA	K3	D.P. 3	—
	1000 V/2000 mA	K4	none	—
OHMS	2 K Ω	K4	D.P. 1	K Ω
	20 K Ω	K3	D.P. 2	K Ω
	200 K Ω	K2	D.P. 3	K Ω
	2000 K Ω	K1	none	K Ω
	20 M Ω	none	D.P. 2	M Ω

Table 2. Autoranging Summary.

Fig. 11 illustrates the up-range and down-range points for autoranging. The VOLTS function is shown, although the MILLIAMPS function operates identically, except that the units are in mA instead of V and the maximum limit is 2000 mA. The OHMS function has one additional range, but the up-range point is still a count of 2000 and the down-range point is still a count of 179.

Fig. 12 is a decision chart of the autoranging logic scheme, which also includes the range lock mode.

Range Lock

When the LOCK mode is selected, the program is changed to inhibit up-range and down-range stepping. The microcomputer stays locked in whatever range was selected when the LOCK switch was operated. The only exception is that if the microcomputer is locked onto range 5 (20 M Ω range) in the OHMS function, it will automatically down-range to range 4 if the VOLTS or MILLIAMPS function is selected while still in the LOCK mode. Otherwise, an inoperative mode would result.

In the LOCK mode, an underrange count is ignored and a reading may be obtained at less than maximum resolution. An overrange count actuates a divider which divides down the 60 Hz backplane signal to roughly 3 Hz. This 3 Hz square wave is applied to all unselected decimal point outputs, which causes them to flash on and off at 3 times per second.

Continuity Buzzer

The microcomputer controls operation of the continuity buzzer. The buzzer drive signal is generated only when several pre-conditions are met. The OHMS function and LOCK mode must be selected and the microcomputer must be locked onto the 2 K Ω range. With these pre-conditions, an underrange count (179 or less) will activate the continuity buzzer by gating the output of an audio oscillator to the buzzer.

The continuity buzzer is additionally controlled by the microcomputer, in that the audio oscillator is enabled only when the K Ω symbol is displayed. The microcomputer output which displays the K Ω symbol is also the gate control for turning on the audio oscillator.

CONTINUITY BUZZER

Refer to Fig. 13, which is a schematic diagram of the continuity buzzer circuit. Exclusive OR gates IC6C and D are connected as an audio oscillator operating at approximately 1800 Hz. As mentioned in the microcomputer circuit analysis, the oscillator is enabled by the microcomputer only when the K Ω symbol is displayed.

The continuity buzzer turn-on signal from IC7, pin 37 is a pulse train. These positive-going pulses are filtered at the base of Q5 by C19. Q5 remains on for the duration of the pulse train. Thus, Q5 is a dc switch in series with buzzer I-1.

Driver Q8 is also in series with the buzzer. It is driven by the audio oscillator at the 1800 Hz rate, causing an 1800 Hz current to pass through the buzzer, causing it to sound.

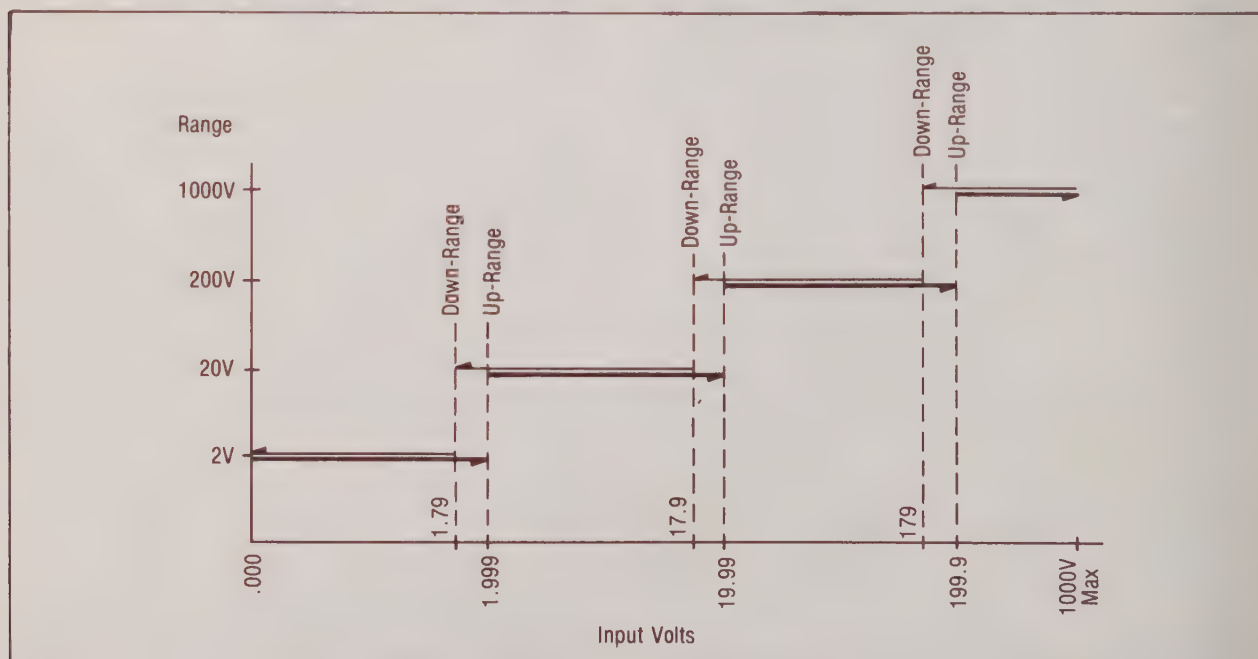


Fig. 11. Up-Range and Low-Range Points.

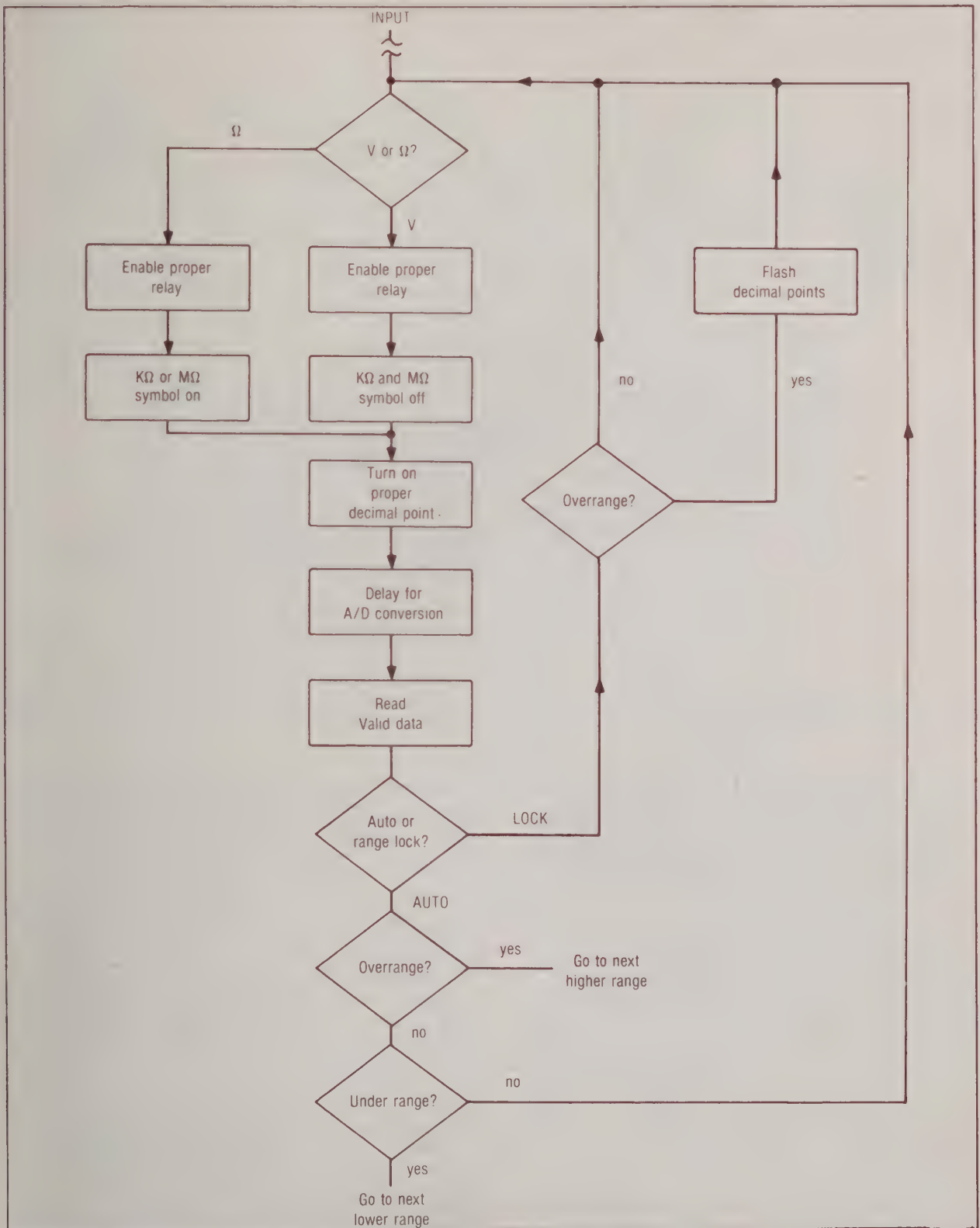


Fig. 12. Autoranging logic diagram.

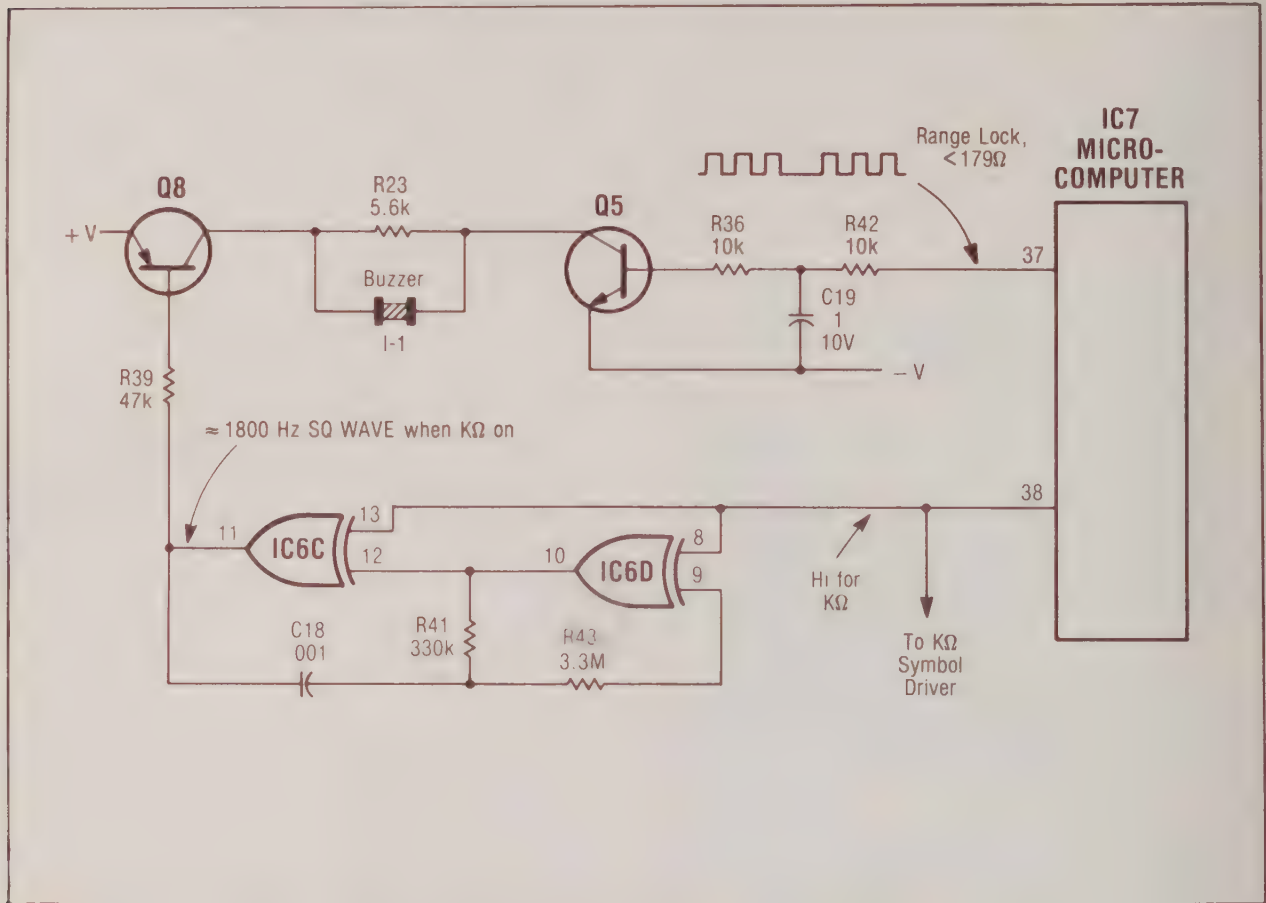


Fig. 13. Continuity Buzzer Circuit.

RELAYS, RELAY DRIVERS, AND RELAY REGULATOR

Refer to the circuit diagram shown in Fig. 14. Range selection relays K1 thru K4 are reliable reed-type relays with sealed contacts. Only about 2.5 mA coil current is required to close the relay contacts. This permits their use in battery operated equipment.

The relays are controlled by the microcomputer. However, the high impedance outputs of the microcomputer do not have the power to drive the relays directly. Relay drivers Q1 thru Q4 perform this function. Drivers Q1 thru Q4 are transistor switches, providing the necessary drive to energize the relays. Relay regulator Q7, which is in series with whichever relay driver is activated, regulates relay coil current to 2.5 mA over a wide range of battery voltage. Battery voltage varies from 10 volts at full charge to 6.5 volts at replacement.

DECIMAL POINT AND SYMBOL DRIVERS

Although the segments of the numerals and minus sign in the 3-1/2 digit display are driven directly from IC2, the decimal points and KΩ and MΩ symbols are controlled by the microcomputer and driven independently. Exclusive OR gate

IC5A thru C and IC6A and B are phase drivers which convert the logic high or low outputs of the microcomputer into 60 Hz drive for the display. Each circuit is identical to the typical circuit shown in Fig. 15.

The 60 Hz square wave backplane signal from IC2 is applied to one input of each exclusive OR gate. The other input is either a logic high or low state from the microcomputer. For a logic low input, the output of the gate is in phase with the backplane signal. The corresponding decimal point of symbol is not displayed. When the microcomputer applies a logic high, the output of the gate is out of phase with the backplane signal and the corresponding decimal point or symbol is displayed.

Overrange in the range lock mode produces an approximate 3 Hz square wave on all decimal point outputs of the microcomputer. This causes the drivers to produce an alternate in phase and out of phase output, which flashes the decimal points on and off. The microcomputer's decimal point output for the selected range was already in a continuous high logic state, and that decimal point remains on continuously.

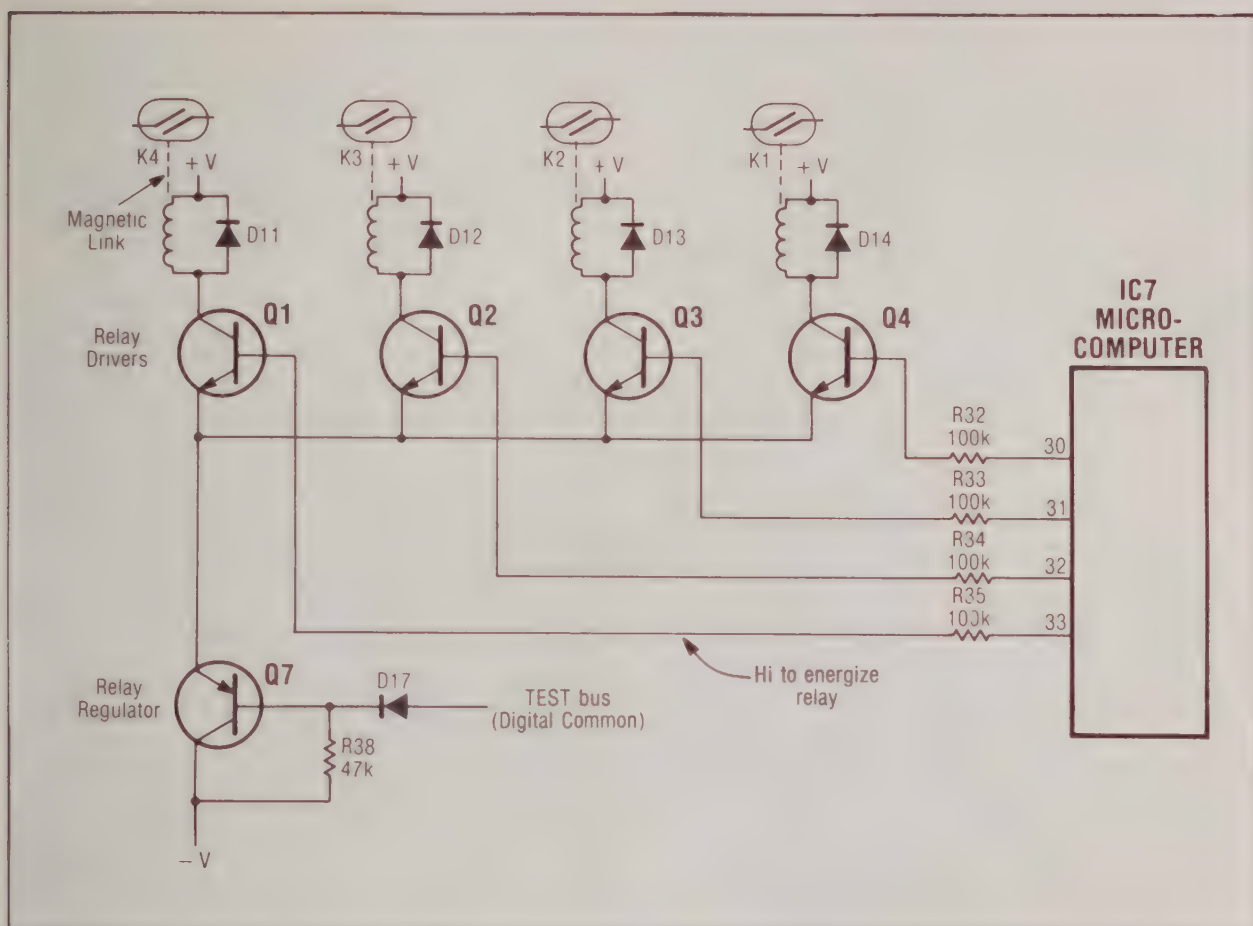


Fig. 14. Relay Circuits.

LOW BATTERY DECODER AND DRIVER

The LO BAT segment of the display is driven by a circuit similar to Fig. 15, except that the logic high or low input to the exclusive OR gate comes from the low battery decoder instead of from the microcomputer. Fig. 16 shows the low battery decoder and driver circuit.

The TEST bus voltage is applied to the base of low battery decoder Q6. This voltage is regulated with respect to +V. Battery voltage is applied across voltage divider R29 and R30, and a proportion of total battery voltage is applied at the emitter of Q6. At normal battery voltage, the emitter of Q6 is negative with respect to the TEST bus and Q6 is turned on. The resulting logic low state applied to LO BAT driver IC5D produces a segment drive signal that is in phase with the backplane and the symbol is not displayed. As the battery discharges, the voltage at the emitter of Q6 becomes progressively less negative with respect to the TEST bus. When the battery discharges to roughly 7.4 volts, Q6 turns off. A logic high state is then applied to the LO BAT driver, producing a segment drive signal that is out of phase with the backplane signal and the LO BAT symbol is displayed.

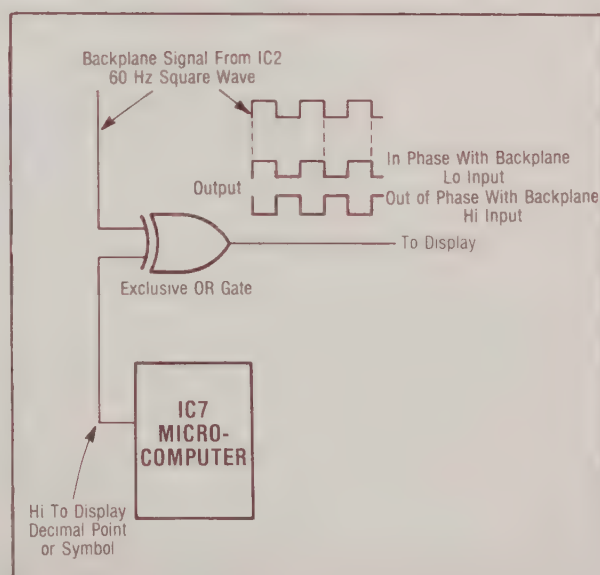


Fig. 15. Typical Decimal Point or Symbol Driver.

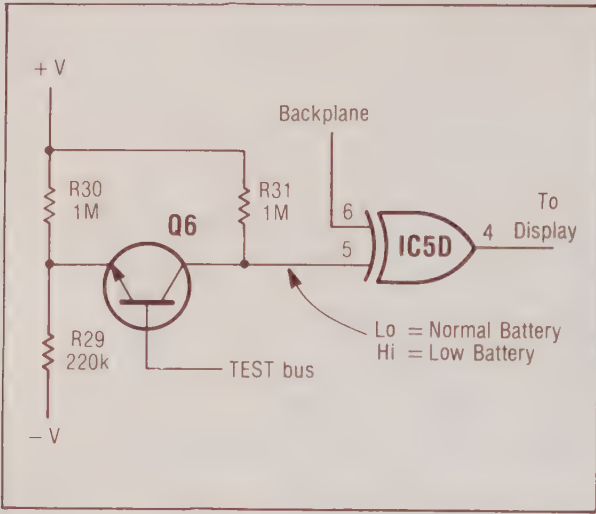


Fig. 16. Low Battery Decoder and Driver.

AUTO SKIP CIRCUIT

The auto skip circuit gives faster settling time for voltage measurements above the auto skip threshold of approximately 23 volts. If the initial input is greater than threshold, the auto skip circuit interrupts the microcomputer and steps to range 3. Two up-range steps of the autoranging sequence are eliminated and settling time becomes less than 1.5 seconds for any voltage reading. The circuit responds to a dc input voltage of either polarity or an ac input.

Fig. 17 illustrates the auto skip circuit. Essentially, the circuit compares a sample of the input voltage to a reference voltage. When the input sample exceeds the reference voltage, the logic state of the comparator output changes. The transition of the comparator output interrupts the microcomputer, causing it to select range 3.

A 0.23 volt reference voltage is established in the reference voltage divider network at the junction of R26 and R40 and applied to the non-inverting input of comparator IC3A. This

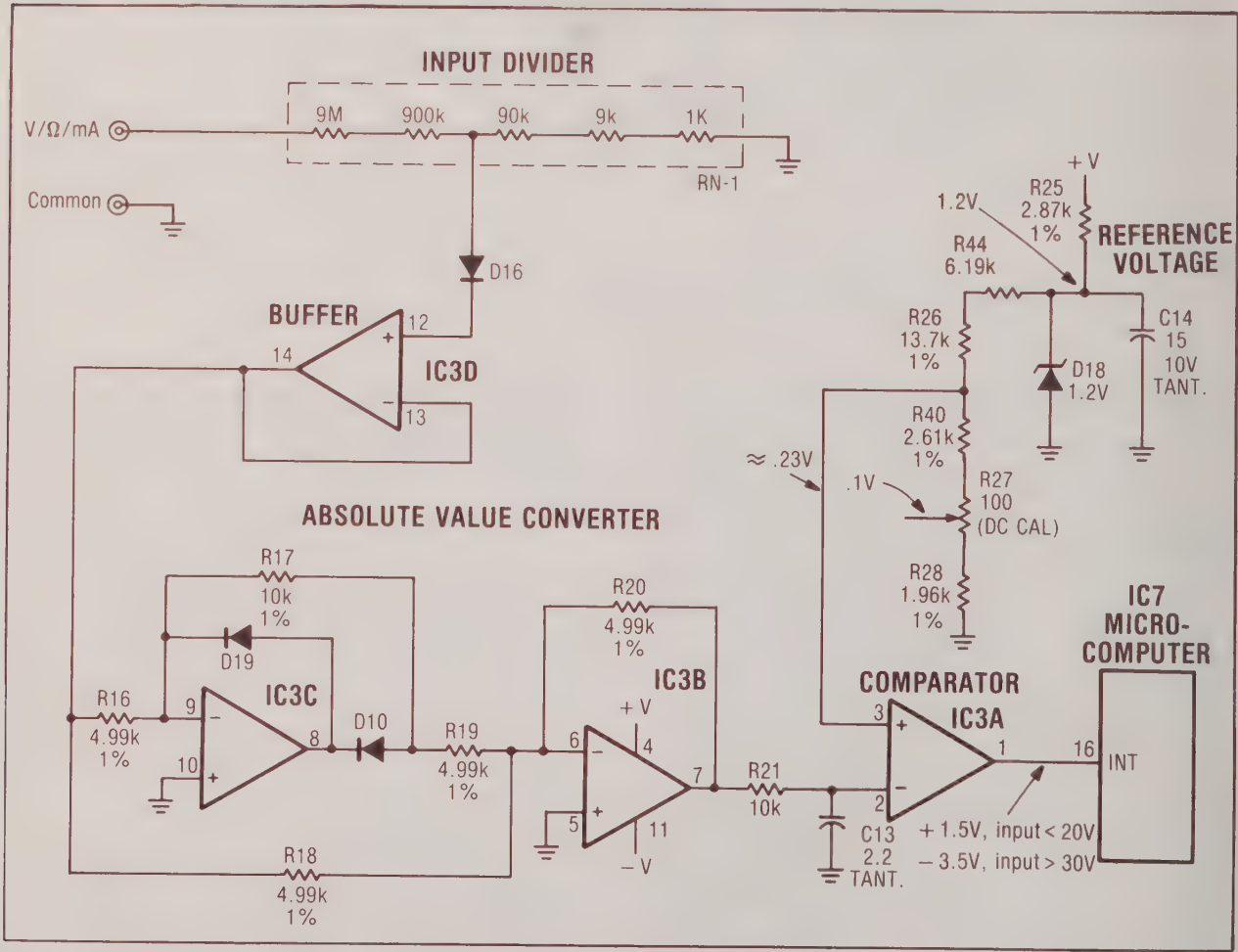


Fig. 17. Auto Skip Circuit.

may be called the comparator threshold voltage. When the voltage on the inverting input of the comparator is below this threshold, the comparator output is in the high state. When the inverting input exceeds the threshold voltage, the comparator output switches to the logic low state. The voltage at the inverting input of IC3A is always of positive polarity, but is otherwise an approximate 100:1 attenuated sample of the input voltage applied to the meter. Thus, an input voltage exceeding roughly 23 volts will cause the input sample to exceed the comparator threshold of 0.23 volt.

If the pre-conditions for the microcomputer are met (VOLTS function and range 1 selected), it accepts the high-to-low transition of the comparator output as an interrupt and skips to the range 3 condition. When the microcomputer is no longer on range 1, it ignores the interrupt and reverts to normal autoranging operation.

The input to the auto skip circuit is a sample of the input voltage, taken at the 100:1 tap of the input divider. The 100:1 sample is applied to high input impedance buffer IC3D, which is a voltage follower that drives the absolute value converter without loading the input divider. The absolute value converter, IC3B and C, is a voltage follower that provides a voltage value essentially equal to that at the output of the buffer, but its output is always of positive polarity, regardless of whether the input is positive or negative. When the input is positive, diodes D10 and D19 are reverse biased and IC3C operates as an inverter. IC3B operates as another inverter and the output to IC3A is of positive polarity. When a negative polarity input voltage is applied, diodes D10 and D19 become forward biased, effectively removing IC3C from the circuit. The inverting action of IC3B converts the negative in-

put into a positive polarity into IC3A. Network R21 and C13 provide filtering of an ac voltage.

A nominal 23 volt threshold is chosen and typical threshold is normally 20 to 26 volts. This assures that cumulative op-amp offsets and component variations do not cause auto skip below 19.99 volts in any circumstances, which would prevent maximum resolution.

POWER SUPPLY

The meter operates from a 9-volt transistor battery or an external dc power source applied at the battery eliminator jack. A voltage of 6.5 to 11 volts provides normal operation. Zener diode D3 offers reverse polarity protection. It becomes forward biased and shorts any reverse polarity power source. In the reverse direction, it gives overvoltage protection at 12 volts, including transient protection.

The battery is floating. The positive terminal (+V) is about +3.2 volts and the negative terminal (-) is about -6.8 volts with respect to analog common for a fully charged battery. Values are proportionately less as the battery discharges. Never connect a test lead from the common input jack (analog common) to any non-common point in the meter, because the meter will be damaged. This is why the common test lead is removed for checking battery voltage.

Of particular significance to service technicians are the separate analog common and digital common. Use analog common (common test jack) as reference for measurements in the analog circuits, and digital common (TEST bus) as reference for measurements in the digital circuits. Digital common is regulated at about -5 volts with respect to +V by a regulator in the A/D converter.

OPERATOR MAINTENANCE

WARNING

To prevent electric shock, disconnect test leads from equipment under test before replacing battery or fuses, or removing the rear case from the instrument for any reason. Do not operate the instrument unless the rear case is in place and fully closed.

MEASURING BATTERY VOLTAGE

The LO BAT indication appears whenever battery voltage is below approximately 7.4 volts. Meter accuracy is retained down to 6.5 volts. If the LO BAT indication appears, be sure battery voltage exceeds 6.50 volts before making any measurements. This meter can measure its own battery voltage without removing the case by using the following procedure (refer to Fig. 18):

CAUTION

Use the $\overline{\Omega}$ (hot) test lead *only*. The meter will be damaged if the $\perp$ (common) test lead is used.

1. Select the VOLTS function, DC mode, and AUTO mode.
2. Remove the black test lead from the meter.

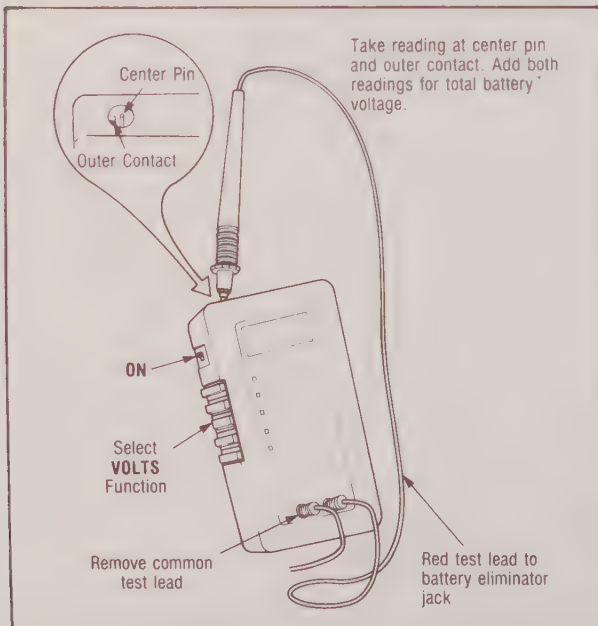


Fig. 18. Measuring Battery Voltage.

3. Using the $\overline{\Omega}$ test lead only, first touch the probe tip to the center pin, then to the outer contact of the battery eliminator jack. Two readings will be obtained. The center pin produces a negative polarity reading (typically, -4.1 to -6.8 volts, depending upon degree of battery charge). The outer pin produces a positive polarity reading (typically 2.4 to 3.2 volts).
4. Add the two readings to find the total battery voltage. For example, readings of -4.43 and 2.36 volts means that battery voltage is 6.79 volts.

BATTERY REPLACEMENT (Refer to Fig. 19)

This instrument operates from a standard 9-volt transistor battery. An alkaline type is preferred for longer battery life, but a carbon-zinc type will also work. Select the battery from Table 3.

A battery must be installed when the meter is initially placed in service, and whenever the battery discharges to 6.5 volts. Remove a discharged battery immediately to prevent instrument damage from battery leakage. Remove the battery if the meter is to be placed in storage, or if it will be unused for several months.

1. Turn power switch OFF.
2. Loosen the two captive screws on the back of the meter and lift off the rear case. The battery compartment is now accessible.
3. Remove the battery from its compartment.
4. Unsnap the battery cable from the old battery and snap it onto the new one.
5. Place the new battery in the compartment, making sure it seats properly in the space provided before replacing the rear cover of the meter.

CAUTION

If the Model 2845 is operated from the Model BE-16 Battery Eliminator without a battery installed, faulty operation may occur if the terminal of the battery clip touches the rf shield. This will in no way harm the instrument except to give erroneous readings on the display. It is recommended that a battery be installed whenever the instrument is in use, or the contacts covered with an insulating material.



Fig. 19. Battery and Fuse Replacement.

FUSE REPLACEMENT (Refer to Fig. 19)

Fuse F1 protects the meter from overvoltage damage and fuse F2 protects the meter from overcurrent damage. If F1 is

blown, all subsequent voltage readings are zero. If F2 is blown, all subsequent current readings are zero. Both fuses are located under the rear cover.

1. Disconnect the test leads from the equipment under test and turn the power switch OFF.
2. Loosen the two captive screws on the back of the meter and lift off the rear case. The fuses are now accessible.
3. Pull the fuse from the fuse clips by the fuse puller strap. The fuse fits very tightly into the clips, and it may be necessary to hold the circuit board in place while pulling.
4. Be sure the fuse puller is around the new fuse before inserting it. Use only a fuse of the correct voltage and current rating. F1 = 250 V, 1/16 A. F2 = 250 V, 2A.
5. Avoid repeating the condition that caused the overload.

TEST LEADS

Periodically examine the test leads to insure that the conductors are not intermittent and do not have broken strands. For safety, inspect insulation for any burns, cuts, or breaks. Do not use test leads if any wire strands are exposed. Also make sure that good contact pressure exists at the test lead jacks and that contact surfaces are free from dirt and corrosion.

TYPE	NEDA	Burgess	Everready	Mallory	Panasonic	Ray-O-Vac
Carbon-Zinc	1604	2U6	.216	—	006P	1604
Alkaline	1604A	—	522	MN1604	6AM6	—

Table 3. Battery Selection Table.

CALIBRATION

This instrument should not require calibration unless repairs have been made that change the factory calibration. Prior to calibration, the instrument should be checked for proper operation of all functions and for damage from physical abuse or excessive overloads.

Recalibration requires a low-impedance constant-voltage source (voltmeter calibrator) of 0.01 % accuracy or better for dc and 0.1 % or better for ac. Use of a voltage source with less accuracy reduces the accuracy of the meter proportionately. Adjustments *must* be performed in the sequence listed. Refer to Fig. 20 for location of calibration adjustments.

1. Remove the rear case from the meter, but leave the component cover in place. When ready to adjust the AC CAL potentiometer, R11, lift the rf shield for access to the adjustment.
2. Set up the meter for dc voltage measurement.
3. Apply +1.900 volts and adjust DC CAL potentiometer R27 for a reading of 1.900.

4. Set up the meter for ac voltage measurement.
5. Apply 1.900 volts rms low-distortion sine wave at any frequency from 50 Hz to 400 Hz and adjust AC CAL potentiometer R11 for a reading of 1.900.

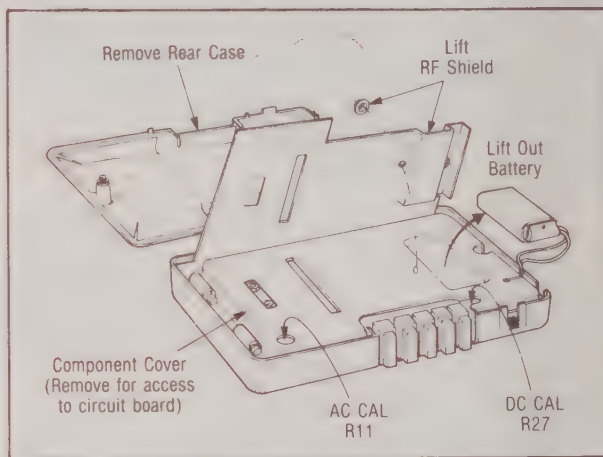


Fig. 20. Disassembly and Location of Calibration Adjustment.

TESTING AND TROUBLESHOOTING

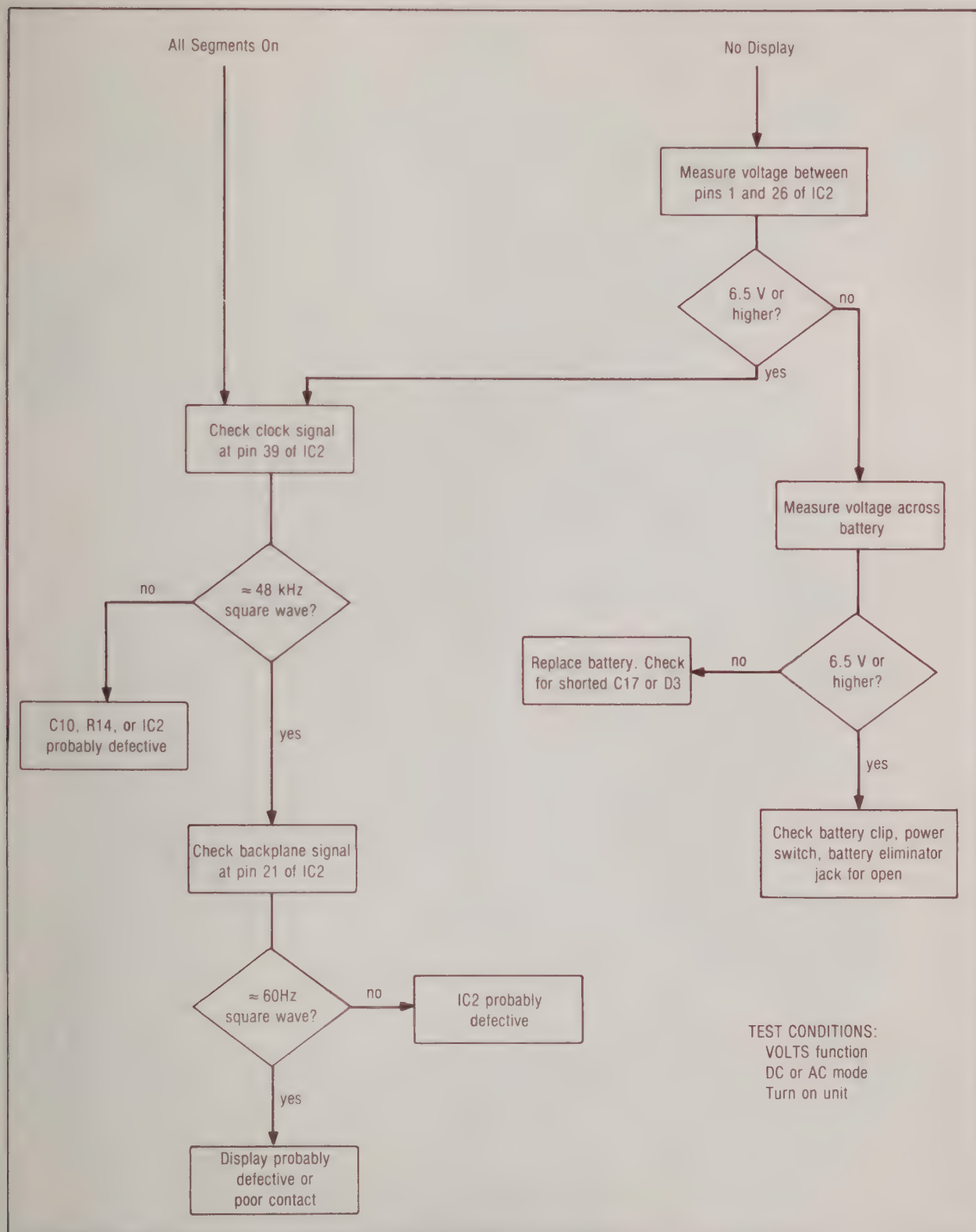
Virtually all testing and troubleshooting can be performed without applying high voltage, which is desirable because it eliminates the danger of electrical shock. Most circuits can be checked for proper operation, and troubleshooting performed if required, in the OHMS function by measuring resistors of 1 k Ω , 10 k Ω , 100 k Ω , and 1 M Ω . Any problem in the display, A/D converter, microcomputer, range relays or relay drivers, decimal point or symbol drivers, input divider, or continuity buzzer will produce symptoms in the OHMS function. If the problem is not found with these checks, a few additional tests will check all circuits not used in the previous tests. This includes measurement of an ac voltage (a low voltage may be used), auto skip test (less than 30 volts required), low battery check, and current measurements. The following "Performance Testing" procedures specify testing techniques which eliminate high voltage, and these procedures are recommended.

PERFORMANCE TESTING

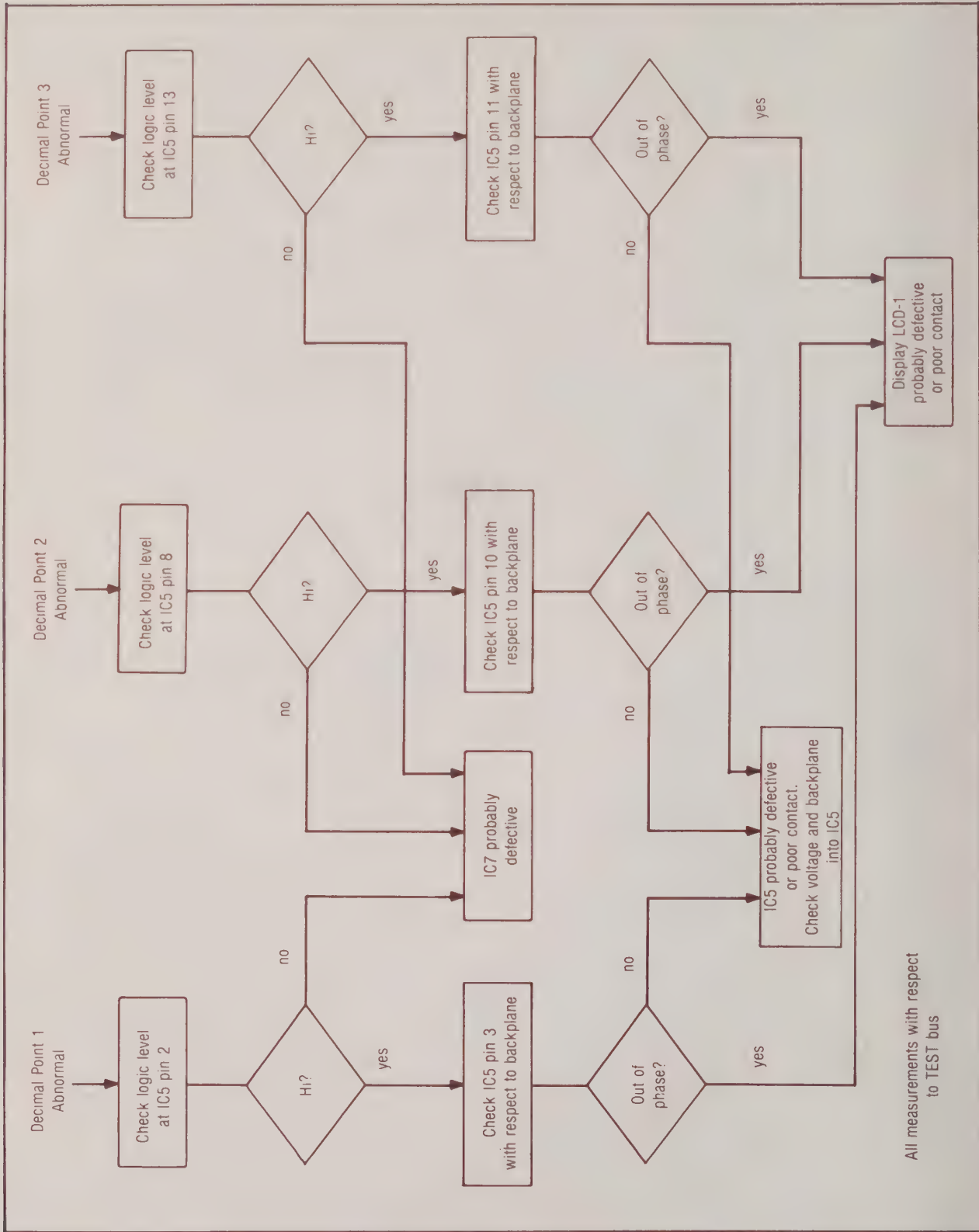
The following performance testing steps provide a check list to assure that all functions and modes are checked for proper operation. After repairs are completed, all functions should be rechecked for proper operation. The steps also serve as a testing sequence guide, identifying symptoms in an organized pattern which helps localize the fault. If a symptom is noted in step 1, for example, it should be corrected before continuing the test. A troubleshooting chart is provided for most symptoms to aid in isolating and correcting faults.

1. Select the AUTO and DC modes and the VOLTS function. Turn the power switch ON. The meter should display a .000 reading. Check the digits and decimal point for normal display.
 2. Measure the battery voltage as shown in Fig. 18. The center pin should read -4 to -7 volts and the outer contact should read 2.4 to 3.2 volts. A zero reading may indicate that fuse F1 is blown. If the minus sign is missing or is displayed continuously, A/D converter IC2 is probably defective.
 3. Connect the meter test leads across a 1 k Ω resistor and select the OHMS function. Check for display of the K Ω symbol and display of correct value. Connect the test leads to the resistor before selecting the OHMS functions so that the meter is not required to up-range and down-range. Up-ranging and down-ranging will be checked in subsequent steps.
 4. Measure a 10 k Ω resistor. Check for proper up-ranging, proper decimal point placement, and correct value displayed.
 5. Measure a 100 k Ω resistor. Again check for proper up-ranging, decimal point placement, and correct value displayed.
 6. Measure a 1 M Ω resistor. Again check for proper up-ranging, proper decimal point placement, and correct value displayed.
- Steps 3 thru 6 may be performed with a 1 megohm potentiometer, slowly increasing the measured resistance and noting that the meter up-ranges through the first four ranges.
7. Open the test leads. Check for display of the M Ω symbol and flashing of the decimal points (overrange indication). If decimal points are displayed normally in all previous steps, but fail to flash for overrange, replace IC7.
 8. Short the test leads together and check for down-ranging.
 9. If the meter up-ranges and down-ranges through all five ranges, check that the meter will LOCK onto each range, and that it does not remain range locked when the AUTO mode is selected.
 10. With the test leads shorted and a display of .000 K Ω , select the LOCK mode. Check for operation of the continuity buzzer. A complete check should be made using a 200-ohm potentiometer and verifying that the buzzer will operate for all displayed values of 179 and less.
 11. Return to the AUTO mode and VOLTS function. Measure a calibrated dc voltage of 1.900 volt and check accuracy, which should be within 3 counts. If a calibrated dc voltage source is not readily available, an approximate check of accuracy may be made by touching the red test lead probe tip to the 0.1 volt reference at the wiper of DC CAL potentiometer R27. A reading of approximately .100 volt should be displayed. Recalibrate the meter if required.
 12. Select the AC mode and measure a calibrated ac voltage of 1.900 volts. Check for a reading of 1.900 ± 13 counts. Recalibrate the ac/dc converter if required.
 13. Select the DC VOLTS function. Measure the output of a dc power supply set at 30.0 volts. Note that auto skip occurs (instant jumping of decimal point when probe tip is touched to the voltage). Set the power supply at 20.0 volts and repeat the measurement. Note that auto skip does not occur. Reverse the polarity and repeat.

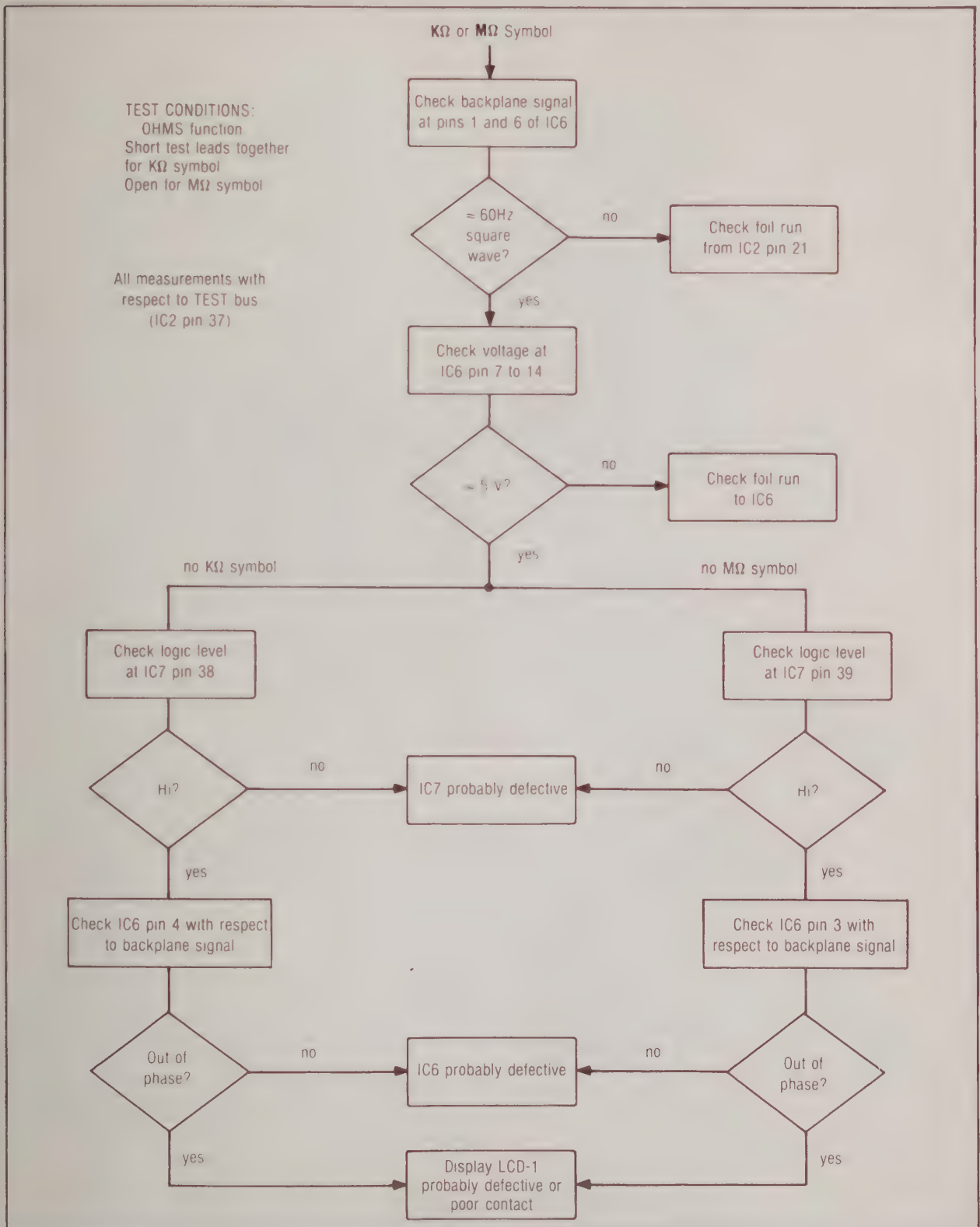
14. If a weak battery is available (6.5 to 7.0 volts), install it and check LO BAT indication. An alternate method is to remove the battery and connect a well filtered dc power supply in place of the battery, carefully observing correct polarity. LO BAT threshold is typically in the 7.2 to 7.6 volt region.
15. Select the MILLIAMPS function and measure dc current from a current source of 1 mA, 100 mA, and 1 A. Check that correct values are displayed. A current source may be fabricated from appropriate value and wattage resistors driven by a dc power supply of at least 1 amp capability. Select resistor values that will eliminate the need for high voltage.

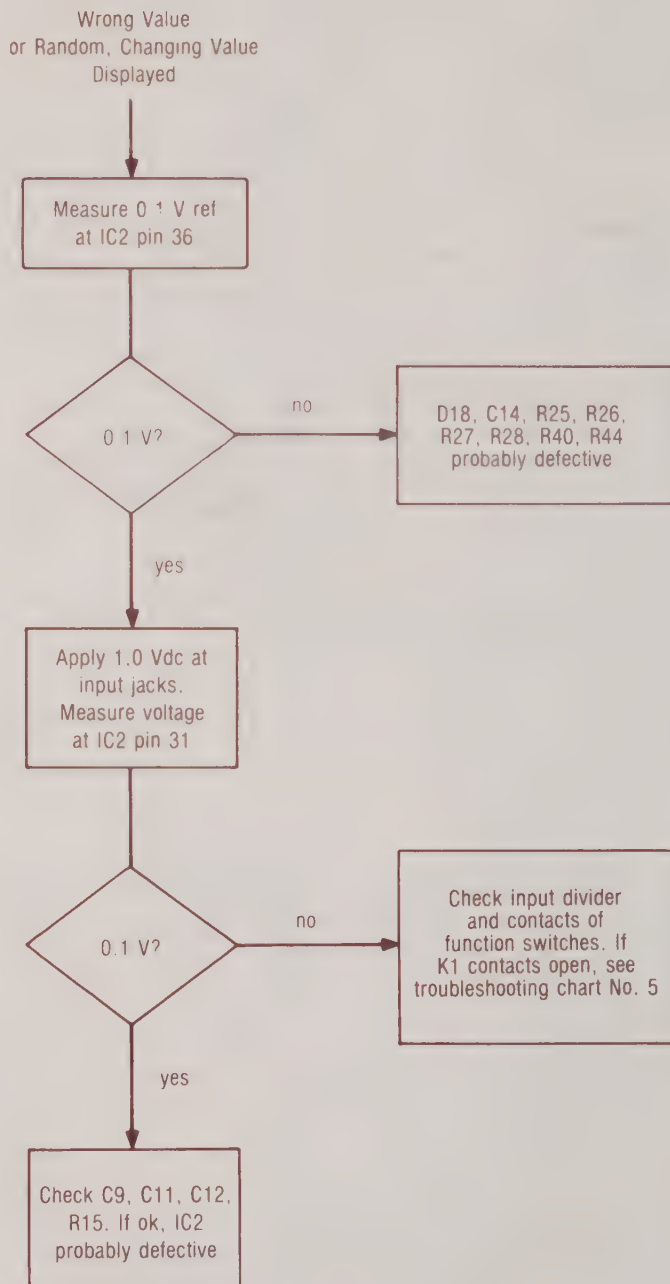


Troubleshooting Chart No. 1. No Display or All Segments On

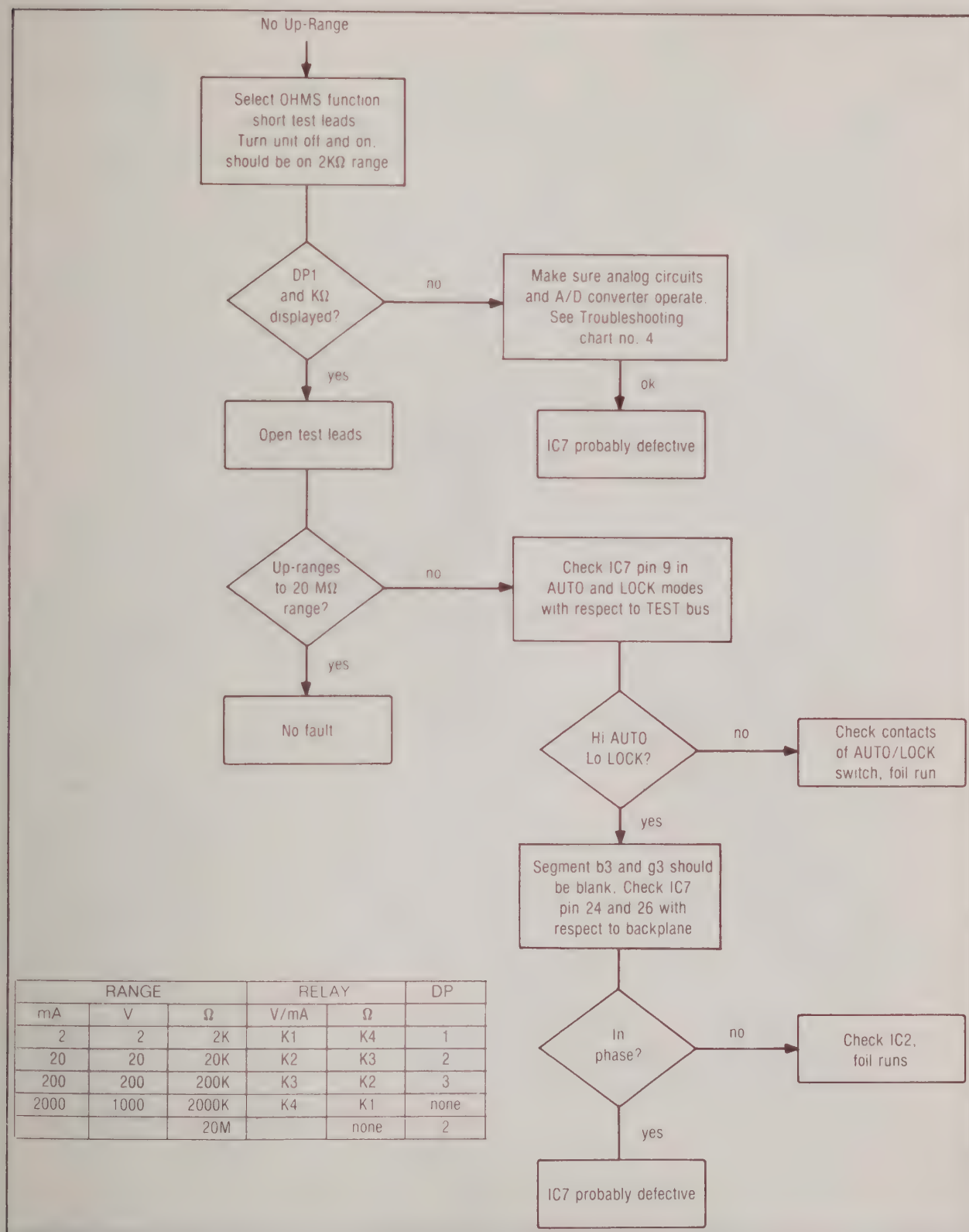


Troubleshooting Chart No. 2. Decimal Point Missing or Always On

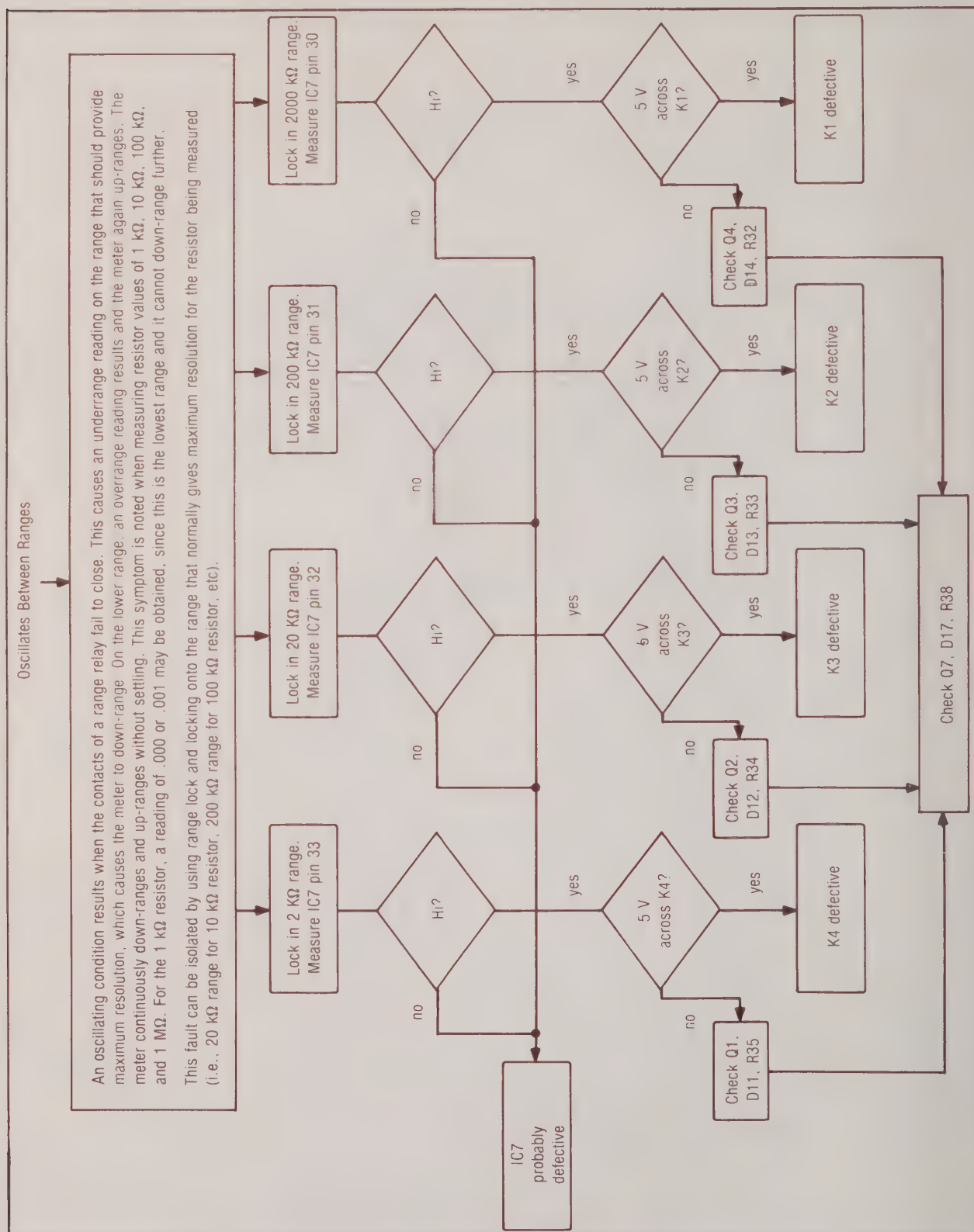
Troubleshooting Chart No. 3. K Ω or M Ω Symbol Missing or Always On



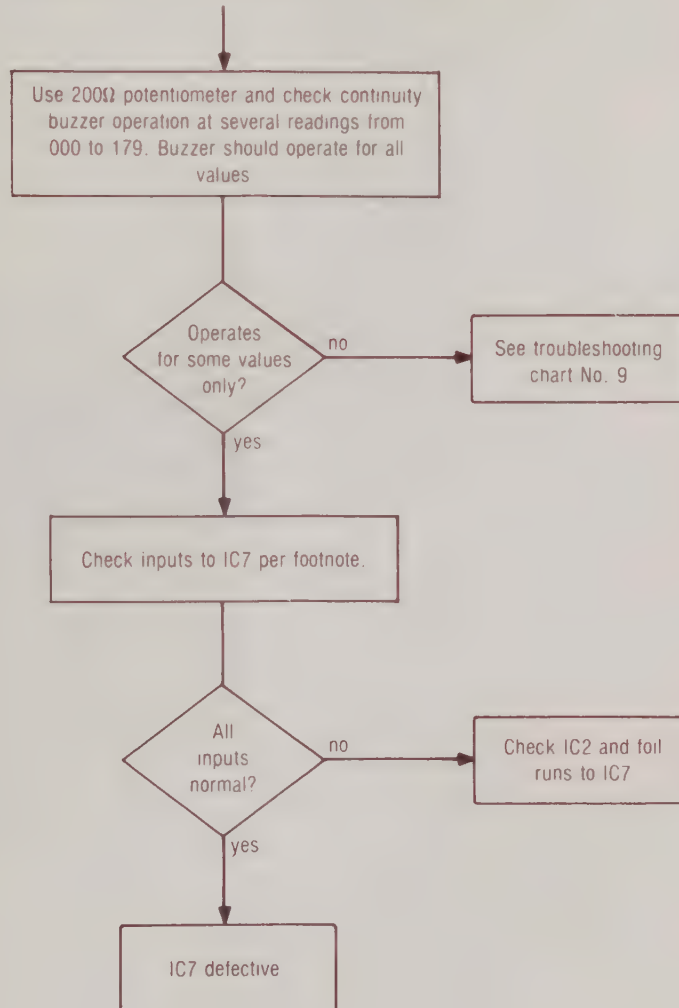
Troubleshooting Chart No. 4. Wrong Value or Random, Changing Value Displayed



Troubleshooting Chart No. 5. No Up-Range

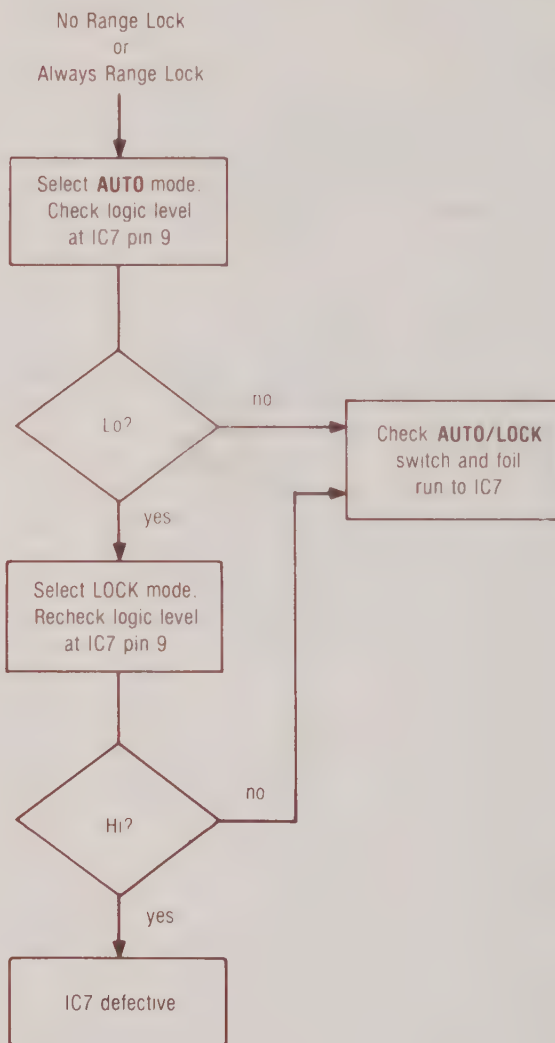


No Down-Range
No Down-Range for Certain Values of Display
No Continuity Buzzer for Certain Values of Display



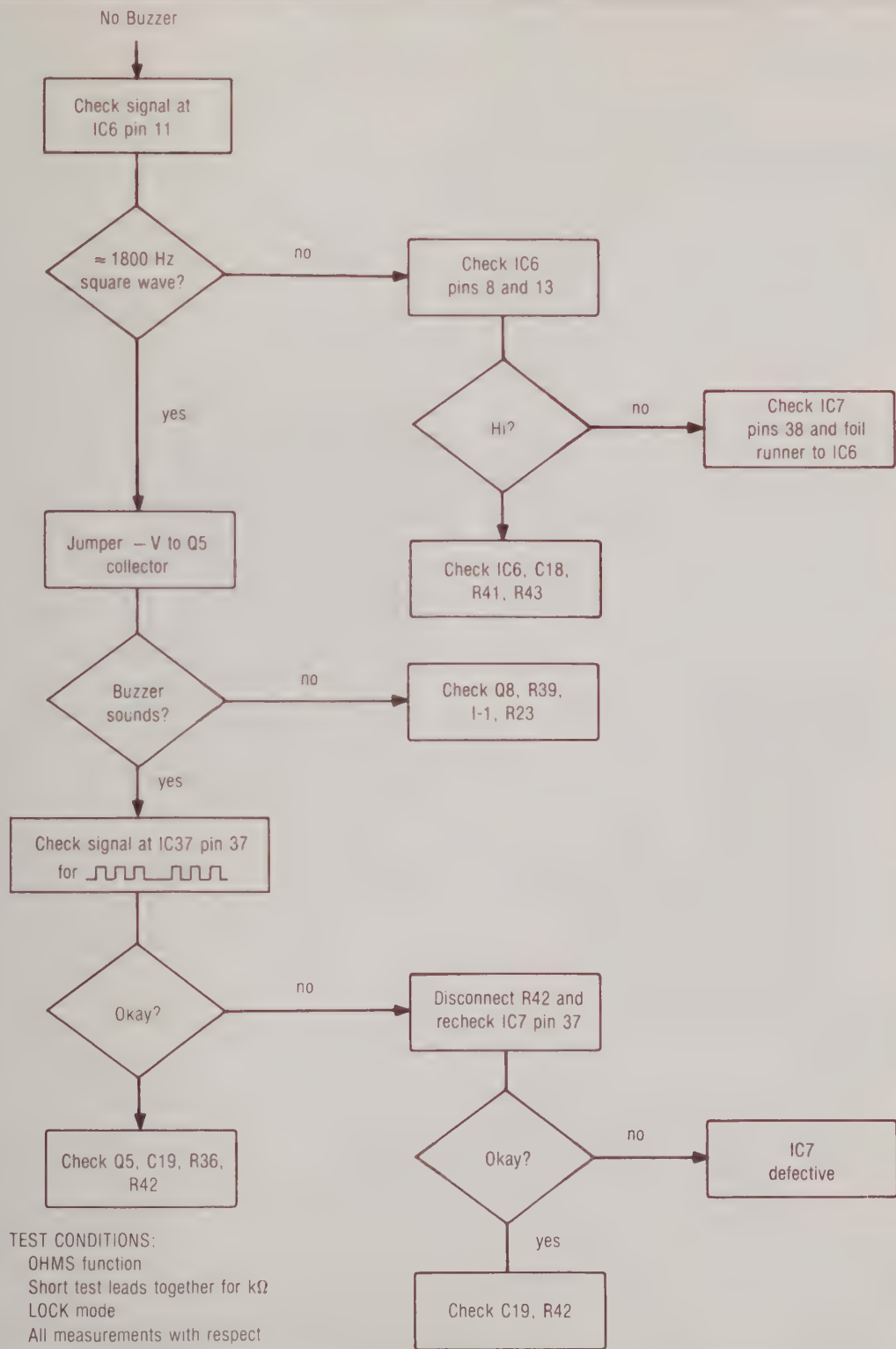
Set potentiometer to display value(s) at which continuity buzzer does not operate. Check inputs to IC7 for display segments a2, b2, f2, g2, a3, b3, d3, g3, and K (fourth digit). Check inputs of IC7 with respect to backplane signal. For each displayed segment, the input should be out of phase with the backplane, and for each non-displayed segment, the input should be in phase with the backplane.

Troubleshooting Chart No. 7. No Down-Range

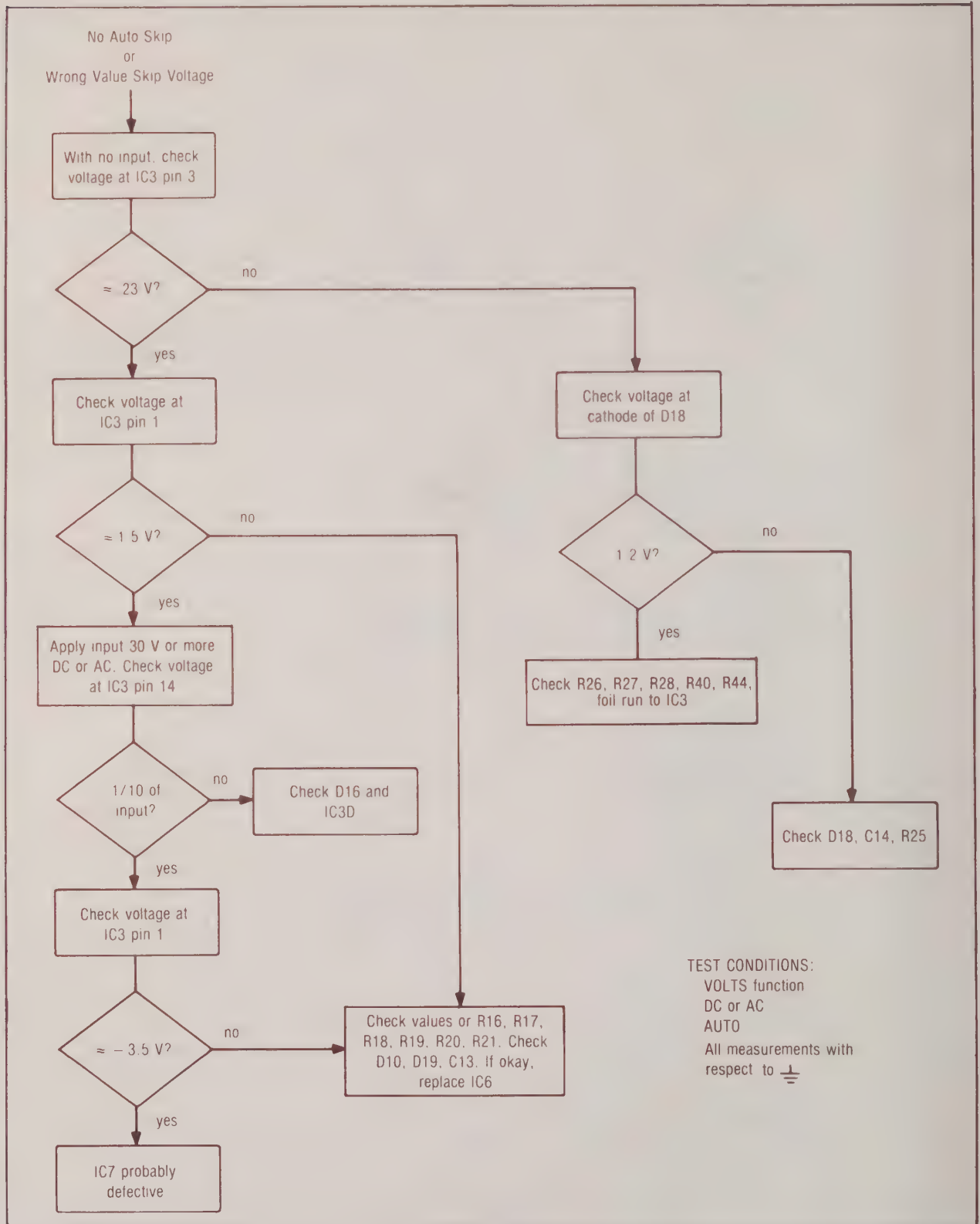


All measurements with
respect to TEST bus

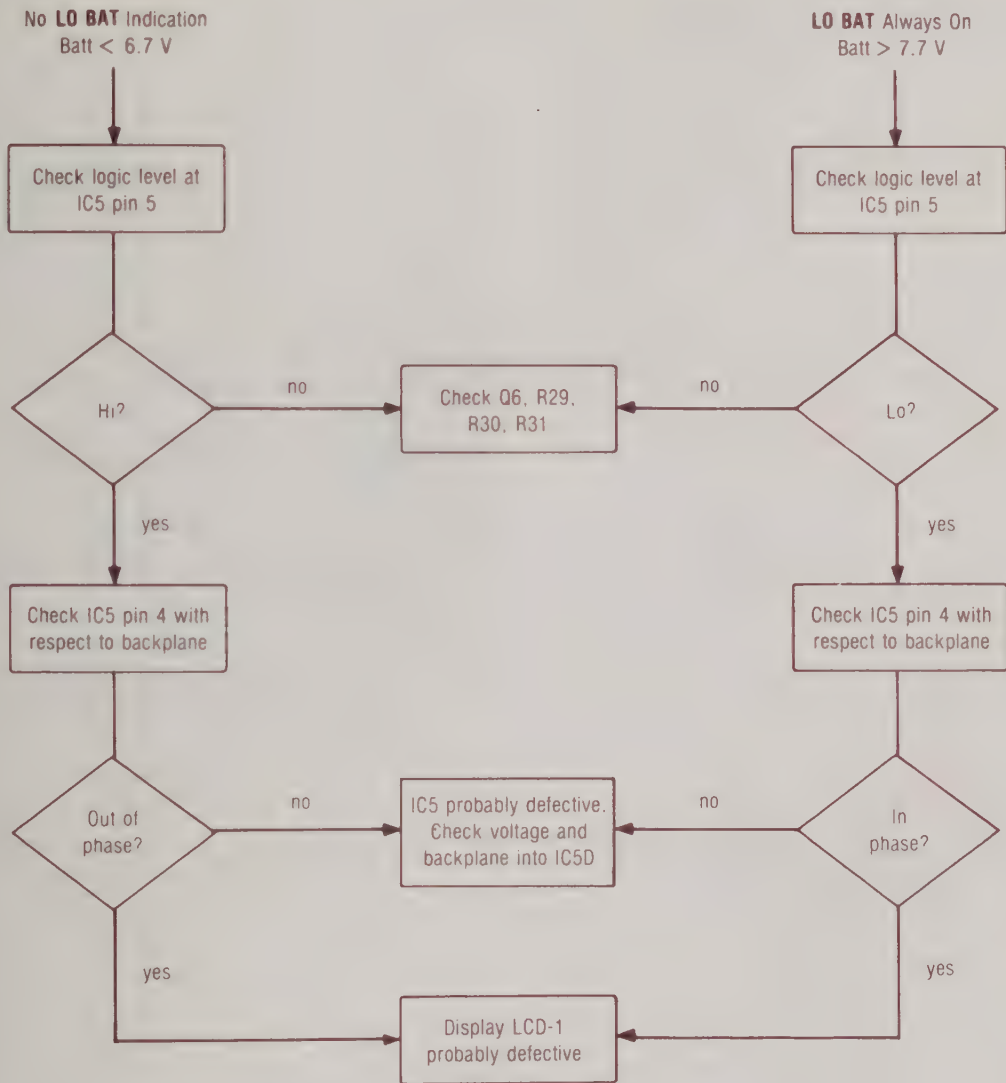
Troubleshooting Chart No. 8. No Range Lock, or Always Range Lock



Troubleshooting Chart No. 9. No Buzzer



Troubleshooting Chart No. 10. No Auto Skip or Wrong Value Auto Skip



All measurements with
respect to TEST bus

TEST CONDITIONS:
Any function
Any mode

Troubleshooting Chart No. 11. Abnormal LO BAT display

DISASSEMBLY

To access the circuit board for troubleshooting and repair, use the following procedure (refer to Fig. 20):

1. Remove rear case as described for battery or fuse replacement.
2. Lift the battery from its compartment and slide the battery wires out the slot, free from the component cover.
3. Remove the retaining nut from the rf shield and component cover.
4. Fold back the rf shield and lift off the component cover.

Most testing and troubleshooting can be performed without further disassembly.

CIRCUIT BOARD REMOVAL

To completely remove the circuit board from the case, such as for parts replacement or to gain access to the solder side of the circuit board or the LCD display, proceed with the following steps (refer to Fig. 21):

1. Remove the nuts and lugs from the test lead jacks (component side of board).
2. The circuit board may now be folded out from the front case for access to both sides.
3. To completely detach the circuit board from the front case, unsolder the two wires that connect to the continuity buzzer (which is attached to the front case).

LCD REPLACEMENT

The LCD (liquid crystal display) is mounted to the circuit board in a special manner that does not require soldering. Contact between the LCD and the circuit board pads is provided by two zebra strips, so called because of their alternating black and white stripes of conductive and non-conductive silicone rubber. Pressure against the edges of the zebra strips maintains electrical contact. The zebra strips are properly aligned by a plastic frame and the necessary pressure is exerted when the LCD bezel is tightened down by its mounting screws. Fig. 21 illustrates the disassembly and re-assembly technique.

1. Remove the circuit board from the meter case.
2. Remove the two screws that attach the LCD bezel. These screws are on the component side of the circuit board.
3. Lift the LCD assembly from the circuit board. Remove the zebra strip frame from the bezel, leaving the zebra strips in place if possible. Lift the LCD from the bezel.
4. To replace the LCD, reverse the procedure. Make sure the zebra strips are properly seated in the slots of the frame. Make sure pin 1 of the LCD is properly aligned with the circuit board pad for pin 1 (not upside down). Refer to the circuit board diagram for orientation.

NOTE

Avoid contamination of the circuit board pads for the LCD. Fingerprints can accelerate corrosion.

PARTS LIST

MECHANICAL PARTS

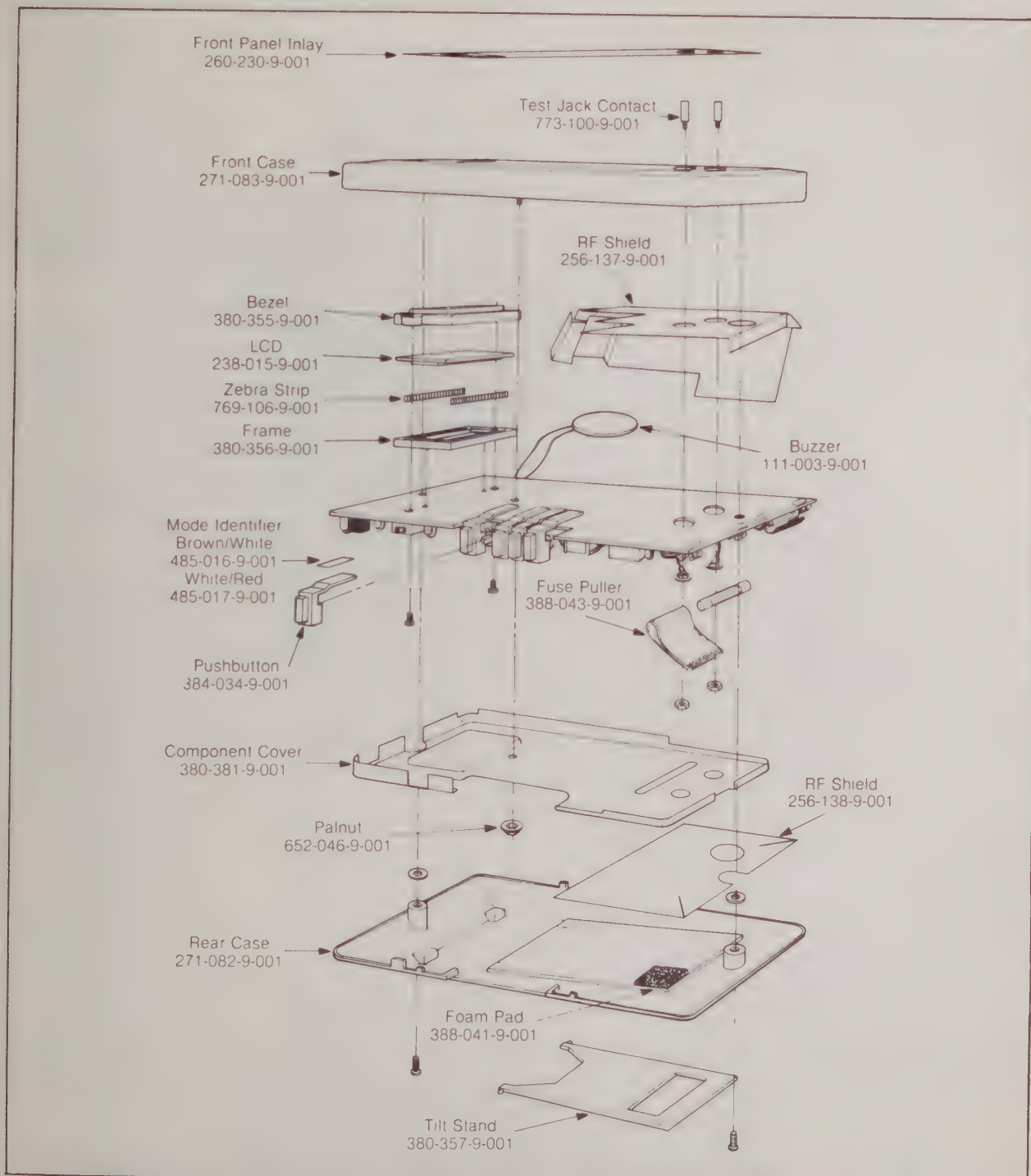


Fig. 21. Exploded View of Model 2845 Autoranging Digital Multimeter.

PARTS LIST

ELECTRICAL PARTS

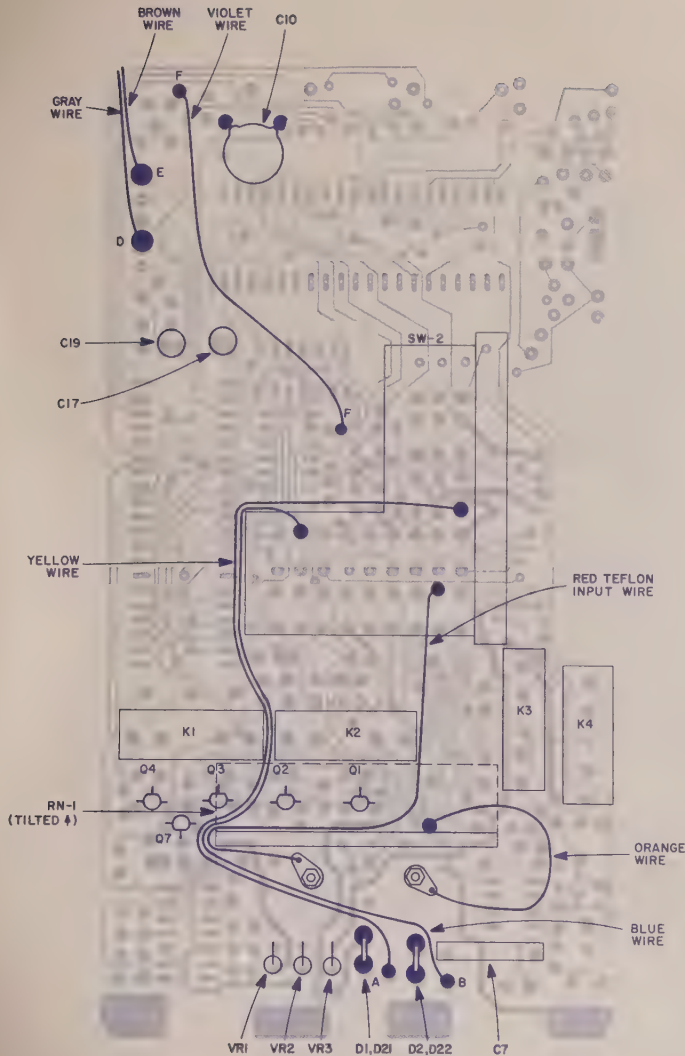
SCHEMATIC SYMBOL	DESCRIPTION	B & K-PRECISION PART NO.	SCHEMATIC SYMBOL	DESCRIPTION	B & K-PRECISION PART NO.
RESISTORS			TRANSISTORS AND DIODES		
R1	90Ω, 1/2W, 1/2% Metal Film	011-171-9-001	D1,2	3A Protection Diode	151-054-9-001
R2	9Ω, 1/2W, 1/2% Metal Film	011-170-9-001	D3	1N4742A, (12V, 1W, 5%) Zener Diode	152-039-9-001
R3	0.9Ω, 1W, 1/2% Wire Wound	004-182-9-001	D4,7,10, 17,19, 20	1N4148, Silicon Diode	151-038-9-001
R4	0.1Ω, 1W, 1/2% Wire Wound	004-178-9-001	D5,6	Graded 1N4148 Silicon Diode (order 2, replace as matched pair)	151-087-9-001
R5,13	1 MegΩ, 1/2W, 5% Metal Film	011-172-9-001	D8	2N5818, NPN Silicon Transistor	176-051-9-001
R8	8.25kΩ, 1/4W, 1% Metal Film	011-177-9-001	D11,12, 13,14,16	1A, 600V Silicon Diode	151-050-9-001
R10, 17	10.0kΩ, 1/4W, 1% Metal Film	011-178-9-001	D15	1A, 1000V Silicon Diode	151-053-9-001
R11	500Ω Trimmer Pot	008-314-9-001	D18	1.2V Reference Zener Diode	152-096-9-001
R12	4.53kΩ, 1/4W, 1% Metal Film	011-175-9-001	Q1,2,3, 4,5	MPS6515, NPN Silicon Transistor	176-050-9-001
R14	105kΩ, 1/4W, 1% Metal Film	011-194-9-001	Q6	2N5818, NPN Silicon Transistor	176-051-9-001
R16,18, 19,20	4.99kΩ, 1/4W, 1% Metal Film	011-176-9-001	Q7,8	MPS6519, PNP Silicon Transistor	177-015-9-001
R24	Special High Voltage-Current Limiter	004-163-9-001	INTEGRATED CIRCUITS		
R25	2.87kΩ, 1/4W, 1% Metal Film	011-174-9-001	IC1	CA3130 OP-AMP	307-073-9-001
R26	13.7kΩ, 1/4W, 1% Metal Film	011-195-9-001	IC2	3-1/2 Digit C-MOS A/D converter	307-168-9-001
R27	100Ω Cermet Trimmer Pot	010-015-9-001	IC3	TL-064 Quad OP-AMP	307-183-9-001
R28	1.96kΩ, 1/4W, 1% Metal Film	011-189-9-001	IC5,6	4030B Quad Exclusive-OR Gate	307-167-9-001
R40	2.61kΩ, 1/4W, 1% Metal Film	011-192-9-001	IC7	μP, 4 Bit	307-184-9-001
R44	6.19kΩ, 1/4W, 1% Metal Film	011-196-9-001	SWITCHES		
VR1,2,3	Metal Oxide Varistor	004-179-9-001	S1	Power Switch, S.P.D.T.	084-075-9-001
RESISTOR NETWORKS			S2	Function Switch (Assembly)	088-057-9-001
RN1	Input Divider	012-022-9-001	MISCELLANEOUS		
CAPACITORS			I1	Tone Transducer	111-003-9-001
C1	1.8pf, 1000V, ± 0.25pf NPO Disc Ceramic	031-051-9-001	F1	Fuse, 1/16A, 250V, 3AG Normal Blow	191-005-9-001
C2	820pf, 500V, 5% Disc Ceramic	020-266-9-001	F2	Fuse, 2A, 250V, 3AG Normal Blow	191-251-3-002
C3,8	.01μf, 100V, 10% Disc Ceramic	020-263-9-001	LCD-1	3-1/2 Digit Liquid Crystal Display	238-015-9-001
C4	.002μf, 500V, 20% Disc Ceramic	020-026-9-001	K1,2,3,4	Reed Relay, S.P.S.T.	447-002-9-001
C5,9	0.1μf, 100V, 20% Polyester	025-109-9-001		Red Test Lead (PR-1 Probe)	523-305-9-001
C6	10μf, 16V, 20% Tantalum	027-030-9-001		Black Test Lead with Insulated Clip	523-300-9-001
C7	0.33μf, 100V, 20% Polyester	025-114-9-001		Fuse Clip (P.C. Mount)	741-126-9-001
C10	91pf, 500V, 5% N750 Disc Ceramic	020-136-9-001		40 Pin IC Socket	762-017-9-001
C11,15	0.47μf, 100V, 10% Polyester	025-160-9-001		Battery Connector	771-037-9-001
C12	0.22μf, 250V, 20% Polyester	025-113-9-001		Test Jack Contact	773-100-9-001
C13	2.2μf, 20V, 20% Tantalum	027-017-9-001		AC Adaptor Jack	773-102-9-001
C14	15μf, 10V, 20% Tantalum	027-009-9-001			
C16	300pf, 500V, ± 5% Disc Ceramic	031-265-9-001			
C17	5μf, 10V Electrolytic	022-112-9-001			
C18	.001μf, 500V, 10% Disc Ceramic	020-155-9-001			
C19	1μf, 10V, - 10/ + 100% Electrolytic	022-138-9-001			

NOTE: Standard value resistors are not listed. Values may be obtained from schematic diagram. Minimum charge \$5.00 per invoice. Orders will be shipped C.O.D. unless previous open account arrangements have been made or remittance accompanies order. Advance remittance must cover postage or express charges. Specify serial number when ordering replacement parts.

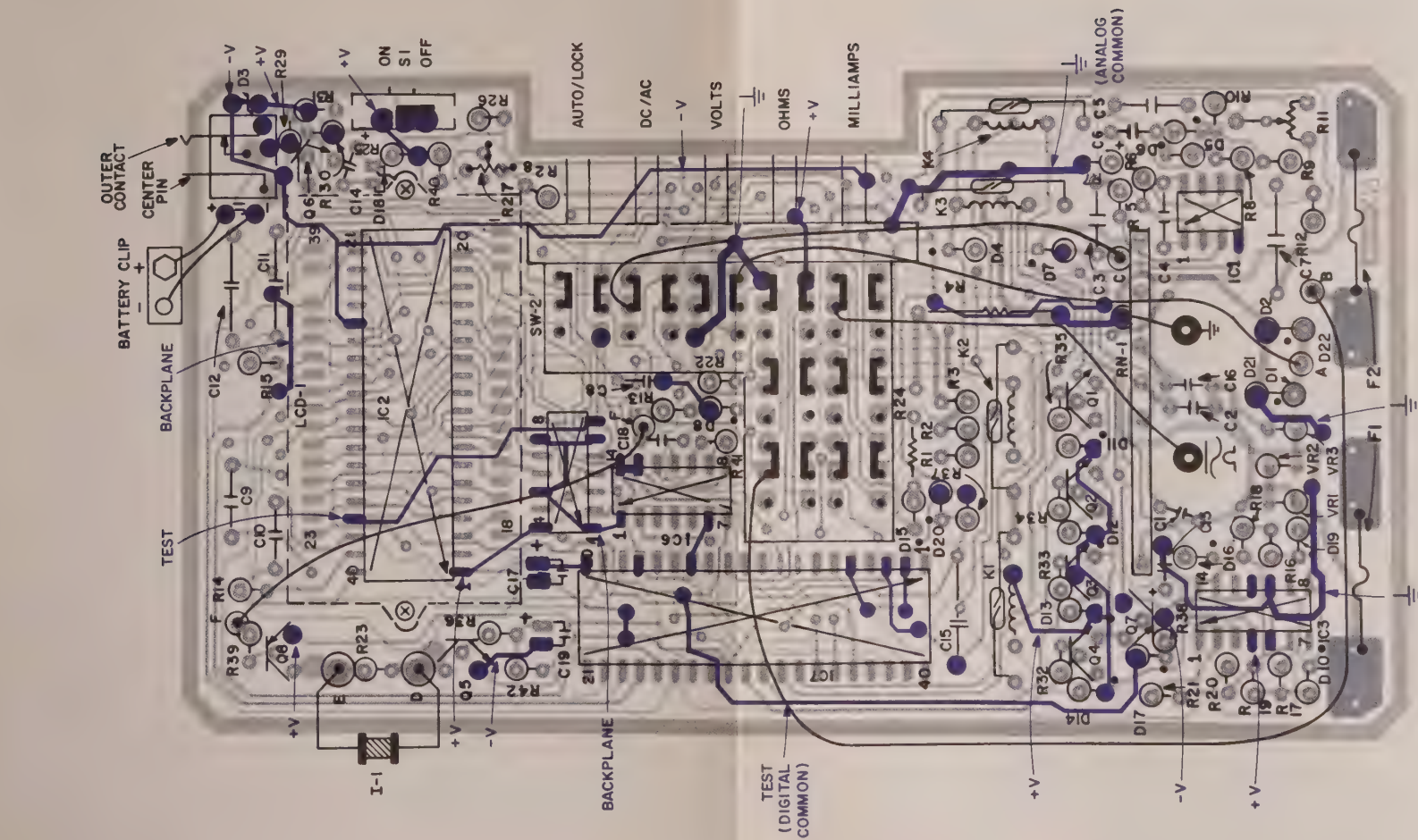
WIRE AND COMPONENT DRESS

To assure that the cover will fit properly, and for proper electrical operation, wire dress and component dress for certain parts must be given special attention when repairs and parts replacement is undertaken, as follows:

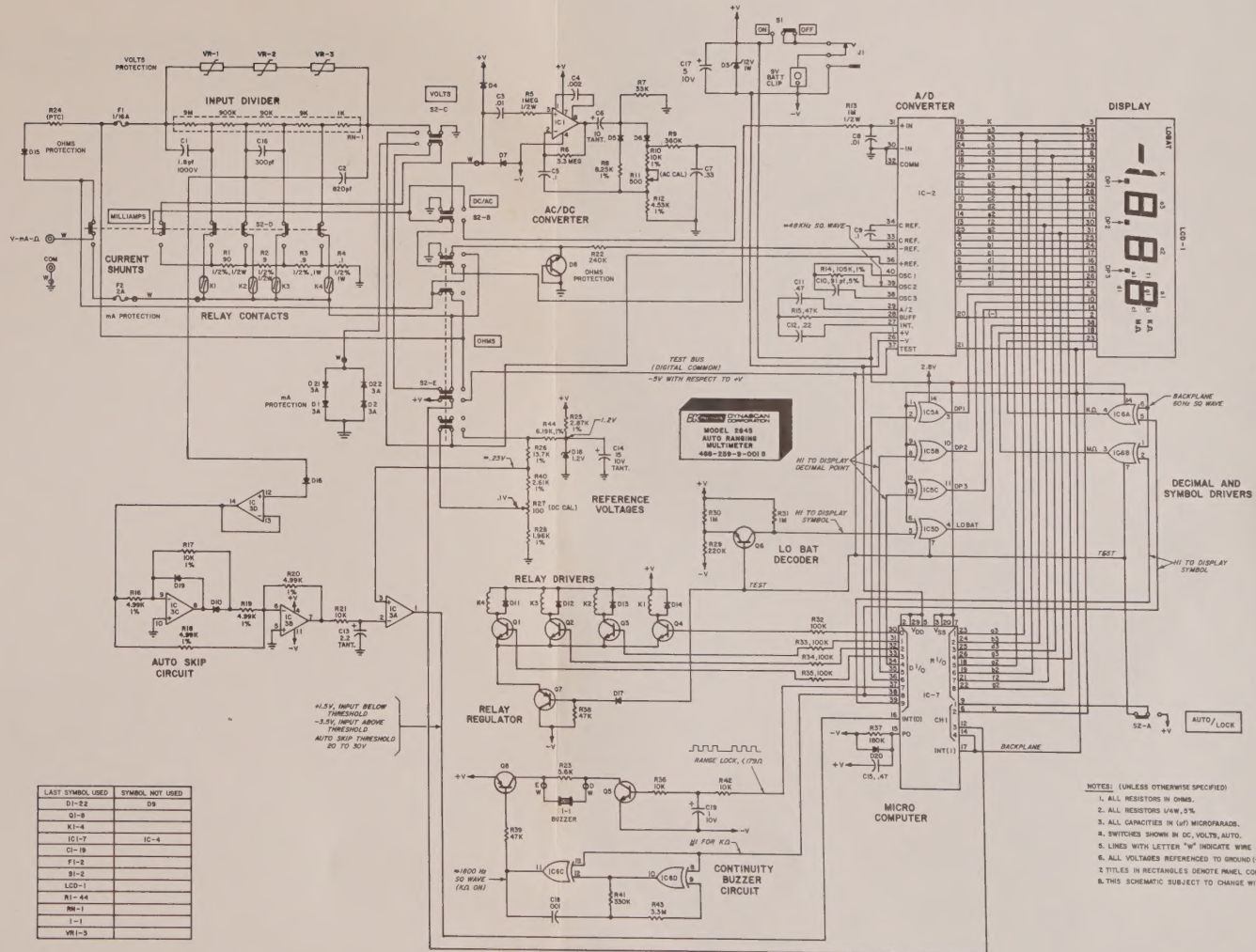
1. All wires must be dressed as shown in the accompanying illustration.
2. Resistor network RN-1 must be raised approximately 1/8-inch off the circuit board, and tilted toward the display to an approximate 45° angle.
3. Capacitors C17 and C19 must be fully seated against the circuit board, and mounted perpendicular to the board.
4. Disc capacitor C10 must be fully seated against the circuit board, then tilted toward IC2. The tilting must be controlled so that the capacitor does not invade the area required for the battery recess in the component cover, nor break the capacitor leads.
5. Transistors Q1, Q2, Q3, Q4, and Q7 must be mounted as close as possible to the circuit board.
6. Diode assemblies D1-D21 and D2-D22 must not exceed the height of capacitor C7.
7. Varistors VR1 thru VR3 must not exceed the height of capacitor C7.



CIRCUIT BOARD MAP



SCHEMATIC DIAGRAM



HISTORY OF PRODUCTION CHANGES

This manual reflects the Model 2845 from the start of production. Watch for any addendums that may be inserted loose into this manual to cover production changes which may occur after the printing of this manual.



6460 W. Cortland St. • Chicago, IL 60635